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Review of current vegetation monitoring on
privately protected land under ongoing
economic use (grazing)

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Snowy capped mountains set the backdrop to the Tui Creek QEII covenant in Rakaia, Canterbury.

Abstract

There has been a noticeable shift in focus in biodiversity research in New Zealand over recent decades. Research has traditionally focused on biodiversity protection on the public estate, which was comprised primarily of ecosystems with lower productive potential (generally over 500m asl). Private lands generally have higher production potential and are often used for intensive cultivation and agricultural practices. They still however have significant potential for protecting biodiversity values. One of the key tools for protecting biodiversity values on privately owned lands in the Canterbury region are through legally binding QEII open space covenants and there is significant potential through industry certifications.

QEII covenants are placed on the land in perpetuity and provide legally binding protection for biodiversity or landscape values within the covenant. This protection is voluntary and allows the land owner to continue to use the land for economic benefit providing it does not prove detrimental to biodiversity through monitoring outcomes. Case studies of QEII covenants that contain grazing clauses in the Canterbury region were used to determine what values are present and what monitoring is occurring in the field within these ecosystems. Photopoints and informal visual monitoring were the primary methods used by the QEII representatives to monitor vegetation in all of the covenants.

Monitoring forms a critical feedback for all biodiversity protection. It is especially important to have an accurate feedback on vegetation condition and change from monitoring on properties that are grazed. Monitoring needs to be capable of providing sufficient information on vegetation change on these sites so that the most suitable grazing levels can be obtained by land managers. This thesis focuses on monitoring methods to ensure that this feedback is suitable and that the methods are cost effective.

Current vegetation monitoring techniques were reviewed to determine which methods would be most suited to monitoring in these ecosystems where resources are tightly restricted and observers may not have existing skills and experience in monitoring these ecosystems. Methods reviewed were quadrats, transects, height-frequencies, photopoints, needle point, biomass, tagged plants, visual rank and remote sensing. Each method is described and then assessed on its suitability for monitoring tussock shrublands, with cost effectiveness being an important criterion. Of these methods quadrats, transects and height-frequencies were the most robust but also the most intensive and least cost effective methods. Visual rank, needle point

and photopoints were the most cost effective, but are generally suited to monitoring single objectives. In most cases a combination of methods would be ideal to suit the objectives of the monitoring. QEII photopoint monitoring should follow guidelines more closely and include more complimentary information with their photographs. Clear monitoring objectives should be developed for every covenant that is grazed and these need to be determined before it is possible to accurately select appropriate monitoring methods. These objectives will also provide the monitoring program with more structure and direction. If possible a detailed management plan for each grazed covenant would be beneficial for values present. QEII are in a unique position, where they have the potential to develop a data base of biodiversity information for private land and contribute to other projects like the National Vegetation Survey (NVS).

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1 Chapter One – Introduction

In the past decade or so there has been a noticeable shift in focus with regards to ecological research and conservation biology (Grimm *et al.*, 2000; Hobbie *et al.*, 2003; Norton, 2000, 2001; Norton & Miller, 2000; Norton & Roper-Lindsay, 2004; Schneider, 2001; Turner, 2005). Previously research publications focused on biodiversity protection on public conservation lands, despite these only accounting for 30% of total land area (Norton, 2001). Research with a focus on privately owned land and lands with mixed tenures is now becoming increasingly more common (Norton, 2000, 2001). While New Zealand has an impressive 30% of its land in the public conservation estate, this figure is very biased towards upland mountainous areas above 500m (Norton, 2001). Less than 20% of lands below 500m are part of the public estate, while some 50% of lands above 500m are within it (Norton, 2001). This is due to the economic production potential of lowland areas and the lack of production potential in some highland sites. These papers have highlighted the problems involved with research that focuses more on biodiversity management on public conservations lands and less on private lands. Norton & Miller (2000) state that some of the biggest problems and challenges for nature conservation lie in those areas most intensively used by humans, where ecosystems become extensively modified and highly fragmented. Some of these areas on privately owned lands provide some of the best opportunities for the long term conservation of a wide range of native species (Norton & Miller, 2000).

This shift in focus has also seen new approaches to managing biodiversity on privately owned lands (Perley *et al.*, 2001). In the past protection was often seen to be effective when the land was simply ‘locked up’ from further economic use. By removing land from land owners you are also removing potentially the most knowledgeable land manager for that land. Some of these new approaches see the land come under legally binding agreements, but allow the land manager to continue to manage the land and use it responsibly for economic benefit. This is win – win as the land is managed by someone who knows the land better than anyone else and the land manager still gets to utilise the land for benefit. One of the main problems of continuing to utilise the land for economic use is the effect of land management decisions on the biodiversity values present. These effects need to be accurately monitored to provide an effective feedback between grazing intensity and the overall impact of land management.

This thesis will attempt to determine whether current monitoring is sufficient to sustain biodiversity values on private land under ongoing economic use. It will follow the shift in research focus towards biodiversity protection on private land and provide recommendations

for improvement where possible. There are a number of different tools and organisations available to assist private land owners / managers in protecting biodiversity values present on their land. One of the more commonly utilised and most robust is the QEII open space covenant, which will be introduced later in this chapter and used as case studies in Chapter 3. Because these covenants are widely utilised throughout New Zealand and are responsible for the largest percentage of voluntary privately protected land in New Zealand (MfE, 2007), they will be used as the primary focus of this thesis. It is important to note that the reason why this thesis is investigating whether biodiversity values are being sustained and not improved is due mainly to the fact that many ecosystems have crossed thresholds due to catastrophic disturbances including Maori and European burning and will never regenerate back into pre settlement primary forest (Hobbs & Norton, 2004). For this reason some covenants may wish to sustain the current biodiversity condition as is, even though it may have exotic species present. The problems that face biodiversity protection on private land will be discussed.

I will later discuss the ramifications from the findings of this thesis for industry certifications. Industry certifications are becoming increasingly sought after by consumers and are becoming a valuable tool for both direct and indirect protection of biodiversity on private land. Direct meaning that to gain and to hold a certification the land manager has to adhere to certain conditions that are designed to decrease the effect that operations have on the surrounding environment. Indirect protection is gained through generating public awareness and allowing customers to demand more environmentally 'friendly' products. Industry certification and QEII open space covenants will both be discussed further, later on in this chapter.

Firstly the current biodiversity condition in New Zealand will be reviewed along with the reasons why it is important to protect. Tools that are commonly used to protect biodiversity on private land will be introduced, with a primary focus on QEII open space covenants. I will then review the most commonly used vegetation monitoring methods in New Zealand (Chapter 2). Case studies will be used to determine what monitoring is occurring in grazed QEII covenants within the Canterbury region (Chapter 3). As well as using the case studies to determine what is occurring in the field in terms of monitoring the organisational frameworks of QEII will also be assessed (Chapter 4). Once it has been determined whether or not current monitoring is sufficient (see figure 1), I will provide recommendations and conclusions about what is working well and improvements that can be made (Chapter 5).

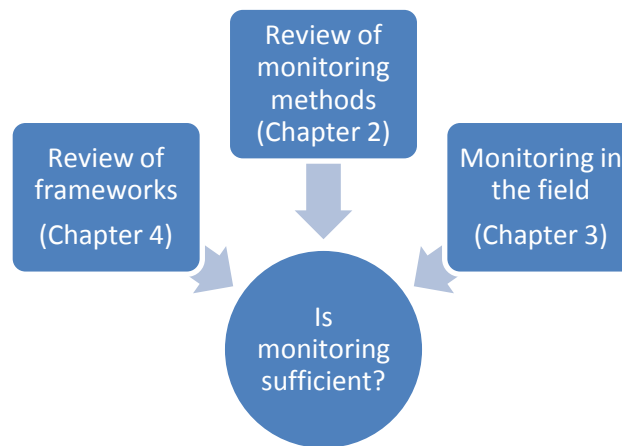


Figure 1: Assessment of the suitability of current monitoring

Chapter one will serve as an introduction to general biodiversity condition in New Zealand and provide an insight into some of the key tools for protecting it on private land. It will provide a context and rationale for the importance of protecting biodiversity on private land in New Zealand. Threats to our native biodiversity will be reviewed as they are an important aspect of managing protected lands. Key organisations involved with protecting and managing biodiversity will be introduced to provide a perspective for QEII's role.

1.1 Biodiversity

1.1.1 An introduction to biodiversity in New Zealand

Biodiversity comprises: individual organisms, effective breeders, geographic populations, species, communities, landforms, landscapes and ecosystems (McFadgen & Simpson, 1996). To gain a detailed view of the overall biodiversity of a particular area or ecosystem, each of these components must be analysed in conjunction with the others (McFadgen & Simpson, 1996). Although measuring these components in their entirety is not possible for large areas, so to obtain a representation of an area, samples must be utilised. The more unique a species or ecosystem is locally, regionally, nationally and globally determines how important its preservation is.

In New Zealand our flora and fauna are very distinct when compared to those from other continents. Prolonged isolated evolution lead to our flora and fauna becoming specialised in quite different ways from other continents and islands due to the lack of mammalian predators

when compared with larger continents. This lack of mammalian predators was thought to be one of the main evolutionary factors that lead to the evolution of our endemic flightless birds. Because many of our native fauna evolved with few mammalian predators, their defence mechanisms are often found to be inferior to those of invasive predators. The uniqueness of our flora and fauna has helped to shape our national and cultural identity.

New Zealand is considered internationally as a significant contributor to global biodiversity (Conservation International, 2007), due to the number of endemic and globally unique species. Of the approximate 80,000 native species present, many are endemic. All of our frogs and reptiles, more than 90% of our insects, about 80% of our vascular plants and a quarter of our bird species are endemic (MfE, 2007). Although a large number of these nationally and globally significant species that are present in New Zealand are under threat. The total number of threatened species reported in the listing exercise carried out in 2004–05 was 2788 (up by 416 from previous counts). There were net increases of 23 species listed in the Nationally Critical category, 32 species in Nationally Endangered and 10 species in Nationally Vulnerable, a reduction of 8 in the total listed as in Serious Decline, and increases of 23 in Gradual Decline, 72 in Sparse and 264 in Range Restricted (Hitchmough *et al.*, 2007). Sixteen birds, one freshwater fish, one reptile, fourteen terrestrial invertebrates and six vascular plants are listed as having become extinct since 1840 (Hitchmough *et al.*, 2007). These figures make us one of the richest, but also one of the most threatened pools of biodiversity in the world and because of this we have been placed on Conservation International's 'hotspot' list. Hotspots are areas that scientists have identified where conservation would provide the most benefit to global biodiversity. Conservation International's list of 34 'hotspots' contain approximately 75% of the world's threatened species (Conservation International, 2008).

From this we see that protecting biodiversity is a crucial task not only for New Zealand's benefit, but for global biodiversity. So the more effective biodiversity protection is the better off national and global biodiversity will be. Many write about the "wonder" that biodiversity possesses and what is truly lost when an ecosystem is destroyed. In the past there was a strong effort to discover or invent new synthetic technologies, but there has been a subtle change of direction which includes investigating what is available naturally. Many scientists believe that there is a huge potential for new medicines and technologies to come from nature (Rennings, 2000). The problem is that many have already been lost and because of their complexity they can never be replicated or brought back. If this trend continues caution would also have to be taken to ensure that biodiversity was not exploited to produce these technologies.

1.1.2 The current status of biodiversity in New Zealand

As mentioned earlier native vegetation cover has changed significantly over the past two centuries in New Zealand. In 2002, 11.7 million ha (43.7% of total land area) was native vegetation cover (MfE, 2007). In a study between 1997 and 2002 it is estimated that 16 500 ha (0.12% of total land area) of native land cover had been converted to other land uses (Walker *et al.*, 2006). (Walker *et al.*, 2006) found that there has been an extreme loss (>70%) in 57% of LENZ land environments and that there is poor legal protection two thirds of these environments. A comparison between LCDB1 (1996/97) and LCDB2 (2001/02) found that there was a loss of 49% in indigenous vegetation cover within this period and that the majority was in already threatened environments (Walker *et al.*, 2005). The vegetation types that have had the most significant decreases in area are broadleaved native hardwoods, manuka and/or kanuka, tall tussock grassland and native forest (Brockerhoff *et al.*, 2008). The two most common changes were to exotic forestry (broadleaved native hardwoods (83%) and manuka/kanuka (52.5%)) or cleared for pasture (broadleaved native hardwoods (12.5%) and manuka/kanuka (46%)) (Walker *et al.*, 2006). This research was however criticised for its lack of accuracy at smaller spatial scales and lack of field investigation to verify the data obtained through remote sensing techniques (Brockerhoff *et al.*, 2008). Close to 60% of New Zealand's vegetation is grassland/shrubland and in less modified situations like the Canterbury high country, provides a high potential to conserve these ecosystems (Wiser & Rose, 1997). Wetlands have decreased by around 90% from their original coverage, a coverage area of 39 068 ha has been protected in accordance with the Ramsar Convention on Wetlands (1971) (MfE, 2007).

New Zealand has a relatively unique undertaking when protecting the large proportion of globally significant endemic species. One positive aspect is the fact that the amount of land that has been legally protected in 2004 was nearly one third (8 210 570ha, 31%) of the total 26 209 052 ha available (OECD, 2007; Rutledge *et al.*, 2004). The majority (8 064 290 ha) of this legally protected land is Crown Conservation Estate (public land) and the other 146 280 ha is in privately protected land (QEII Trust 54 538 ha, Nga Whenua Rahui 83 135 ha and Nature Heritage Fund 8 607 ha) (Rutledge *et al.*, 2004).

In only two years since Rutledge's (2004) report the area of protected land has increased significantly. According to the Ministry for the Environment's latest environmental review in 2007, the total area of protected land was approximately 9 491 473 ha (36% of total land area). This is about a 5% increase in total protected land over just two years. The area of public conservation land increased to approximately 9 270 000 ha which is about a 15% increase and

privately protected land increased to 221 473 ha, which is an increase of just over 50% (MfE, 2007). These increases are the result of a significant change in attitude towards biodiversity protection both in the public and private sectors. The majority of privately protected lands are protected voluntarily by the land owners. Awareness of the importance of protecting our native biodiversity as well as industry benefits have helped to promote legal protection of biodiversity values in New Zealand. Although the increase in protected land has been significant, it should be noted that figures could be affected by the fact that many of these privately protected areas are very small in size and reporting methods may have changed.

One of the drawbacks is that the total area of land under protection is not indicative of the types of environments and biodiversity values that are being protected. As mentioned earlier the majority of legally protected land in New Zealand is on land that has lower economic potential (above 500m), which is usually situated on steeper hillsides, cooler climates, poor soils and higher elevations (Norton, 2000). This means that the biodiversity values present on protected sites are not representative of the broader range of values found on privately owned land throughout New Zealand. Biodiversity values that are normally found on gentle slopes, warmer climates and fertile soils are underrepresented as this land is often converted into economically productive land. Canterbury has been particularly affected by land change; especially on the highly productive and intensively farmed Canterbury Plains.

1.1.3 Biodiversity management

Once land is legally protected it is not ensured that biodiversity values will be sustained. Appropriate ongoing management is crucial to ensure that the goals of the land are met. Invasive species may even establish themselves more easily because the grazing pressures have been reduced or removed. Ongoing and effective management is dependent on ongoing and effective monitoring. A cycle is formed that relies on feedback from management decisions to ensure the appropriate management is occurring (see figure 2). Monitoring vegetation change in response to management regimes is a crucial component of this cycle.

The (OECD, 2007) report outlined a number of recommendations to improve native biodiversity protection in New Zealand. These recommendations included harmonising monitoring of major pressures on biodiversity and ecosystems, both within and outside protection areas and to further develop partnership approaches to conserving biodiversity on private land, prioritising conservation of ecosystems that are under-represented in public conservation lands. The report also recommends that the central government issue national

policy guidance concerning conservation of biodiversity on private land. Recent success in biodiversity protection on private land has in part been due to the voluntary basis of the process. If central government issued national policy guidance this could have detrimental effects on the uptake of formal biodiversity protection. These recommendations have been made with the aim to provide a more centralised structure to biodiversity on private land, as currently it is segregated somewhat between different agencies (see chapter 1.1.4) (OECD, 2007).

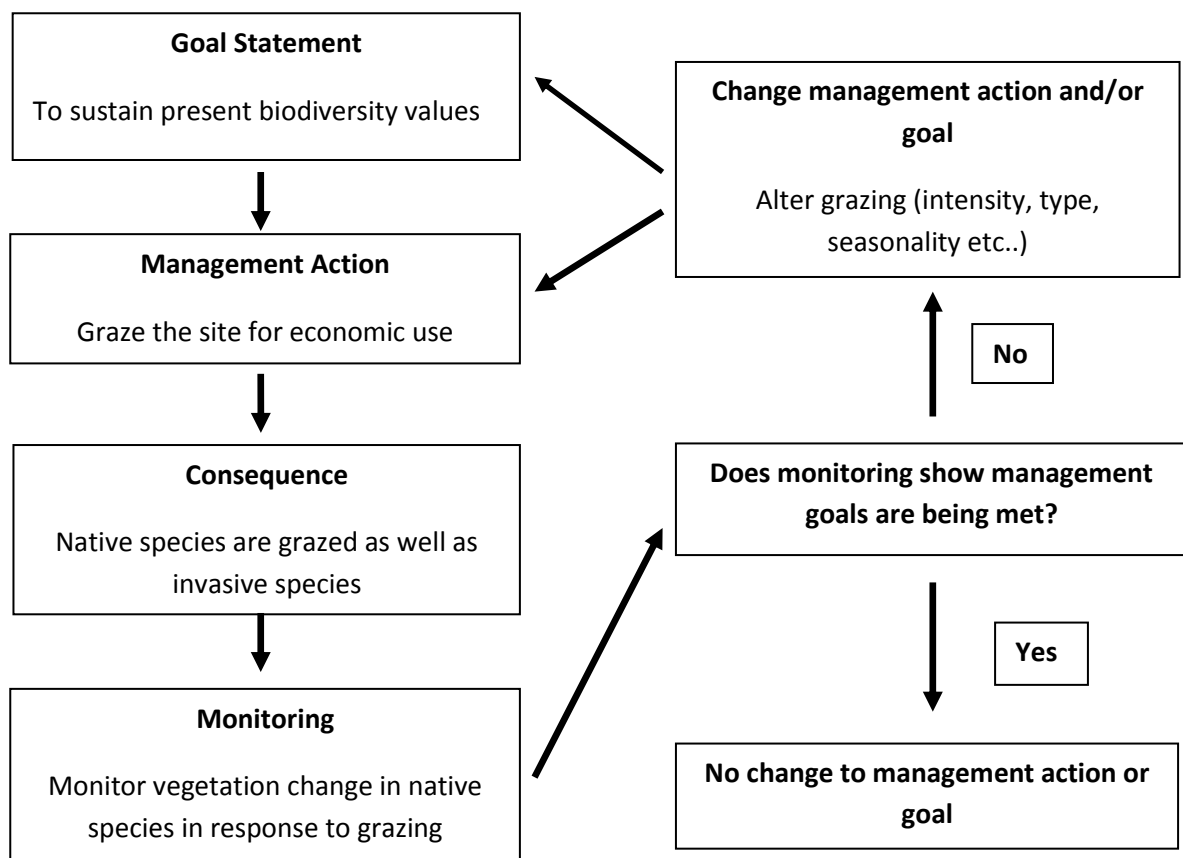


Figure 2, Assessment cycle for management decision in covenants that are grazed

1.1.4 Pressures on and threats to biodiversity in New Zealand

The precise time of arrival and settlement of Polynesians in New Zealand is still a matter of debate but it is commonly believed to have been in the 13th century (Wilson, 2007). From their initial arrival to 1840 the native woody vegetation cover was reduced from 75% to 53%, which included destruction of half the lowland and montane forests, usually by fire (McGlone,

1989). This first period of Polynesian settlement brought about hunting, predation and competition for food and the kiore (*Rattus exulans*) (Holdaway, 1989). The massive reductions in vegetation cover predominantly occurred between 750 and 500 years ago and lead to dramatic reductions in species range and habitats, which also lead to the reduction and/or extinction of many of our native vertebrate fauna (McGlone, 1989). Reduced range/habitat coupled with predation for food also lead to a number of native species becoming extinct, particularly larger native bird species like the moa (DoC, 1994).

This problem was further compounded with the arrival and settlement of Europeans. They brought with them advanced agricultural and horticultural practises and by 1840 native woody vegetation cover had been reduced by a further from 53% to 23%. Fauna was hunted with more sophisticated weapons and *Rattus norvegicus*, *R. rattus*, mustelids, cats, and mammalian herbivores were introduced (Holdaway, 1989). The second wave of vegetation destruction caused further reductions in range and further extinctions of native species (DoC, 1994). Since the original settlement of humans in New Zealand the biodiversity condition has continually declined as human populations have grown and expanded. More land was cleared and prepared to provide the necessary resources to supply this expanding population. Vegetation clearance has continued at a relatively steady rate until recent legislation, new approaches to management and more importantly since awareness has increased about environmental issues.

Today, land use, climate change, nitrogen deposition, biological invasions, and increasing atmospheric CO² levels are seen as the five main drivers of biodiversity change globally (Sala *et al.*, 2000). Of these land use, both through clearance of existing natural habitats especially forests or intensification of land use in existing agricultural areas, is seen as the single biggest threat to biodiversity (Foley *et al.*, 2005; Haberl *et al.*, 2007). While these same five drivers are also important in New Zealand, the single largest threat to native biodiversity today is biological invasions (Perley *et al.*, 2001). While habitat loss has been more important historically and intensification of land management threatens specific values locally, the pervasive impact of biological invaders is affecting all native biota within New Zealand. The changes wrought by humans have been more dramatic than those induced by any natural phenomena over the past three millennia (Holdaway, 1989). Because human settlement has been recent, New Zealand represents one of the best documented examples of the impacts of human settlement on the native biota.

The rise of globalisation has increased the frequency and size of movements of both goods and people around the globe. With these dramatic increases in global movement there is an increasing risk of invasive species being introduced into our native ecosystems. Barbara Hayden (National Institute of Water and Atmospheric Research, Christchurch, New Zealand)

reported that, of approximately 300 000 shipping containers (known vectors for many terrestrial invaders) arriving annually in New Zealand's ports, only about 18% can be inspected (Everett, 2000). Ministry of Agriculture and Fisheries (MAF) Biosecurity as well as other agencies helps to reduce the risk of invasive species making it to our shores and also manage existing threats by following Biodiversity Strategies (2000 & 2003). MAF Biosecurity division has also developed a national pest plant accord that lists 92 species of pest plants that are considered a threat to natural or physical resources or even human health in New Zealand (MAF, 2008). This list is designed to generate awareness of these species and to ensure that they are not willingly distributed or propagated around the country. Biosecurity is an important aspect of managing threats to New Zealand's native biodiversity.

Invasive species have caused a number of extinctions and reduced populations of native species in New Zealand, many of which have been well documented (Green, 2000). Although invasive species have been consistently introduced to New Zealand's shores since the arrival of humans, each has their own individual characteristics, which can range from being highly beneficial to being severely detrimental. Some of these introductions have proven to have significant economic value and have become important aspects of our economy, where as others like sheep and cattle have even helped to define us as a nation. If species that have a negative effect on biodiversity prosper and have detrimental effects on the surrounding flora and fauna they can become a significant regional or even national threat. When they spread uninhibited at a regional and national scale they can become increasingly difficult to manage effectively. When the risk of invasive species being introduced is combined with previously disturbed ecosystems (i.e. land change) the potential threat to biodiversity is greatly increased.

It is difficult to determine the economic loss or potential future economic loss from biodiversity loss or extinctions, which makes it difficult for policy makers to figure outcomes of land management into their budgets. On the other hand the benefits from these invasive species or land change are much more quantifiable as there is usually an established market based around their utilisation. If policy makers are to fully factor biodiversity into budgets, researchers need to find an accurate economic cost-benefit analysis that can be used for current and future species. Developing a model like this would require collaborative research between a range of different disciplines (Hughey *et al.*, 2003). If successful, analysis of this nature would give policy makers a more accurate measure of the value of prevention of loss, protection and remediation of biodiversity (Nunes & Riyanto, 2005).

Another threat to New Zealand's biodiversity (although relatively minor compared to biological invasions and habitat loss) is fire, which can be from natural or anthropogenic ignition. The majority of fires are caused by human carelessness. The Department of

Conservation (DOC) deals with an average of 160 fires per annum, with an average yearly cost of suppression being \$750,000 and an average of 2000 hectares being burnt (DoC, 2008). Effects of fire damage to ecosystems can range from being minor to devastating depending on the prevailing weather conditions and the amount of fuel available. Fires do occur naturally and many ecosystems are resilient to their effects but the increased frequency due to anthropogenic ignition makes it much more difficult for these ecosystems to succeed with regeneration. Fire intolerant species may also be lost with large fires like on the Canterbury Plains (Norton & Miller, 2000).

Species and ecosystems can build resilience to disturbances over time. Many of the ecosystems used as case studies in this research have been grazed for several years or even decades. Many have crossed ecological thresholds due to disturbances (Hobbs & Norton, 2004) and will remain in new or secondary states. The key threats to the case studies used in this thesis are exotic species and mismanagement, which will ultimately lead to exotic species ‘taking over’ the ecosystem. Exotic plant species can be managed by grazing if they are palatable, which is the reason why QEII open space covenants (see chapter 1.1.7) include grazing clauses. Grazers feed on the exotic species and the desirable native species have a better chance at competing for resources. This can work in reverse as well, with grazers focusing on desirable species and allowing exotic species to better compete for resources. For this reason monitoring needs to be able to accurately determine the effects from management decisions (grazing). The purpose of this research is to ensure monitoring effectively measures vegetation change in response to management decisions within QEII covenants.

1.1.5 Agencies involved in protecting Biodiversity

There are a large number of agencies that are actively involved with the protection of biodiversity in New Zealand, many of which are either government agencies or government funded. The level of protection and services on offer from these organisations can vary substantially. For some it is their sole operation and for others it is just part of a range of services that they offer. These organisations are on many different levels and will be categorised into the following groups:

- Government
- Local government
- Indigenous peoples (Maori)
- Research institutions and universities

- Non Governmental Agencies (NGO's)

The following discussion is indicative and by no means exhaustive.

1.1.5.1 Central Government

At the central government level, protection is generally targeted at a nation-wide scale. This is achieved by a number of departments that develop and implement national strategies for protecting biodiversity. These departments provide guidelines for regional governments and agencies. The Ministry for the Environment (MfE) 2000 report suggests that central government's role should involve providing the necessary structures (including funding) to support local governments with local biodiversity protection. They must also maintain a close relationship with these local governments to help implement these structures (MfE, 2000). The Department of Conservation (DOC), the Ministry of Agriculture and Fisheries (MAF), the Ministry for the Environment (MfE), Statistics New Zealand and Te Puni Kokiri – Ministry for Maori development are all involved with the protection of New Zealand's biodiversity at a national level (Anonymous, 2008). Each department will have a different role and cover varying aspects of the protection process, but can quite often work in collaboration with each other and with other agencies. DOC is primarily responsible for implementing conservation strategies and is involved heavily with the preservation and management of native flora and fauna.

The central government provides funding for different agencies and organisations. For many this is their sole income source and they could not function without it. Funding can be direct or through funding pools where anyone can apply. Each pool will have its own aims and objectives that must be satisfied by applicants should they be successful. Criticisms often target the levels of funding provided by the government, because it determines the operational capacity of those who rely on it.

1.1.5.2 Local Government

Local governments are involved at a regional scale, and usually consist of a regional council that covers the entire province and a number of smaller district councils within each region. Regional councils (ECan, EBoP etc) implement strategies that are more detailed and specific

to their region than national strategies. Under the Resource Management Act 1991 (RMA) regional authorities are to include general guidelines for the protection of local acutely threatened species and land that is of regional significance. Regional strategies and plans are likely to be more tailored to work around the main economic activities of the region, as they are crucial to the economic survival of the regions. The criteria for these plans and strategies are set out in schedule 1 of the RMA.

We are seeing an improvement in the collaboration and consultation phases of these strategies as policy makers are waking to the value that organisations can add through experience and expertise. Local conservation groups provide crucial support local governments, who provide the leadership and direction for the region (MfE, 2000). The recent 2008 Canterbury regional biodiversity strategy has seen collaboration between 19 different organisations, including Landcare Research, the University of Canterbury and Fonterra (ECan, 2008). This strategy is the first region wide biodiversity strategy in New Zealand.

The functions and powers of local and regional authorities are set out in part 4 sections (30) and (31) of the RMA. Sections (30)-(36a) of part 4 of the RMA set out the functions, powers and duties of local authorities.

1.1.5.3 Indigenous Groups

The environment is the lifeblood of Maori and their people, as it identifies who they are and where they have come from. They see themselves as stewards of the land, which is reflected in the term Kaitiakitanga, which is stated in the RMA 1991. This principle is summarised by the Kaitiakitanga network as follows:

Kaitiakitanga is something that starts from within one's own self and spreads outwards when we realise that it is our responsibility and the job of our families, communities and all nations to look after all the richness of our world for future generations; a role where we are assistants to our Gods and our ancestors. This is not just about our physical environment and its entire species, but also includes the values, language, culture and wisdom that have been reliably passed down to us over hundreds of generations. Our job is to pass this on to all in a state better than we found it.

(<http://www.kaitiakitanga.net/index.htm>)

The key organisations involved with biodiversity protection from an indigenous perspective include the Federation of Maori Authorities, Te Ohu Kai Moana/ Treaty of Waitangi Fisheries Commission and local iwi or hapu. Issues regarding the Treaty of Waitangi are set out in part 2, section (8) of the RMA. We are also seeing a change in the way Maori are being involved in policy making and resource management in New Zealand. Te Runanga o Ngai Tahu is involved in the Canterbury Biodiversity Strategy and has had an input in the consultation process to represent their needs. It is important that Maori continue to be recognised in land management processes, especially at the consultation stage. Maori own less than 5% of the total land area in New Zealand yet account for almost 50% of the remaining indigenous vegetation on private land. This means that any policies made may affect Maori people disproportionately (MfE, 2000). Therefore it is important to find a balance between Maori interests that does not prejudice or promote their interests in proposals.

1.1.5.4 Research Institutions and universities

Research institutions and universities are at the forefront of innovation and are actively involved in providing accurate and relevant information as well as providing tools for protecting biodiversity in New Zealand. These institutions can gain access to funding from government grants and funds. Universities have access to funding for their research programs through central funding pools. Students have access to scholarships and research funding on an individual basis or as part of a larger research group pool. The crown research institutes involved in the protection of biodiversity are as follows:

- Cawthron
- Landcare Research
- National Institute of Water and Atmospheric research (NIWA)
- Scion

Universities also play an important role through research and education. It is vital to educate future generations and leaders about the environment and tools for protecting it. They are also at the forefront for researching new methods for protecting our biodiversity and assessing the effectiveness of methods that are currently being utilised.

Some of the key universities involved in biodiversity protection are as follows:

- University of Canterbury
- Auckland University
- Lincoln University
- Massey University
- Te Wananga o Aotearoa
- Otago University
- Victoria University of Wellington
- Waikato University

1.1.5.5 Other organisations

There are a large number of organisations that have a vested interest in biodiversity protection in New Zealand. Many of these organisations provide consultancy services to produce environmentally friendly and sustainable outcomes for both public and private sector projects.

Some make a profit through providing a service and others primary goal is to stimulate interest in certain issues. It has been recommended that leadership and direction for organisations that are government funded is provided through local and central government (MfE, 2000).

- | | |
|---|--|
| • Action Biocommunity | • NZ Limnological Society |
| • Animal Health Board | • NZ Native Forest Restoration Trust |
| • Botanical Societies | • NZ Native Orchid Group |
| • ECO | • NZ National Herbarium Network |
| • Ecologic Foundation | • NZ Plant Conservation Network |
| • Federated Farmers | • NZ Recreational Fishing Council |
| • National Possum Control Agencies (NPCA) | • Ornithological Society of NZ |
| • NZ Ecological Restoration Network (NZERN) | • QEII National Trust |
| • NZ Ecological Society | • Royal Forest and Bird Protection Society |
| • NZ Forest and Bird | • Royal Society of New Zealand |
| • NZ Entomological Society | • Seafood Industry Council |
| • NZ Institute of Horticulture | • Seafood New Zealand |
| • NZ Landcare Trust | |

- Society for Research on Amphibians and Reptiles in New Zealand
- Southern Seabird Solutions
- Tane's Tree Trust
- WWF (World Wide Fund for Nature)

It is evident there are a large number of organisations involved in biodiversity protection in New Zealand. OECD (2007) recommends that these organisations are given direction and structure, so that resources can be more effective.

1.1.6 Biodiversity protection tools currently used in New Zealand

The most prominent piece of national legislation for protecting native biodiversity is the Resource Management Act 1991, which aims to provide a sustainable balance between the environment and development. The key sections of this legislation that provide protection for biodiversity are sections (5), (6) and (7) and the responsibilities of management are set out in section (30) and (31). Protection through the RMA is provided through a resource consenting process, where applicants must adhere to certain conditions in order to gain permission to proceed with their proposed activity. During this process the onus is on the applicants to provide all the relevant information on the effects that this activity will have on human welfare and the surrounding environment. This comes in the form of an Environmental Impact Assessment (EIA), which includes any adverse effects from construction through to future use and whether these conform to the statutory requirements of the region in which they are to be built. Any adverse effects to the environment that are not minor must be avoided, remedied or mitigated before the consent can be granted. Some of the other key pieces of biodiversity legislation in New Zealand are as follows:

- Environment Act 1986
- Biosecurity Act 1993
- Crown Pastoral Lands Act 1998
- Hazardous Substances and New Organisms Act 1996
- Forests Act 1949
- Fisheries Act 1996
- Conservation Act 1987
- National Parks Act 1980
- Reserves Act 1977
- Wildlife Act 1953

- Native Plant Protection Act 1934
- Emissions Trading Scheme (enacted, 2008)

There are a number of biodiversity protection tools used by land managers in New Zealand, ranging from legal agreements (Donahue, 2003) to ecological footprint analysis (Fricker, 1998) to industry certifications (Ridolfi *et al.*, 2008). Another tool that land managers can utilise on a case by case basis is biodiversity offsets, which have been utilised in recent Environment Court hearings (Norton, 2009). At a regional level councils can generate lists or schedules of ecologically significant sites, which could be placed onto the regions planning maps. Activities within these areas can then be limited or restricted (Froude, 1999). General regional vegetation controls can also be utilised that distinguish the maximum area of vegetation that can be cleared or the types of vegetations that can be cleared. These can be altered to have different levels of protection for more significant or more sensitive areas (Froude, 1999).

Two important and commonly utilised tools for protecting biodiversity values on private land are legal covenants and industry certifications. These two tools will form the basis for research in this thesis. Legal covenants are placed of the land in perpetuity, so they provide excellent long term protection for biodiversity values on the land. Industry certifications provide the land managers/owners with benefits such as improved market access and branding if they manage their operations more sustainably. Although they are not specifically targeted at biodiversity protection they are still an important tool for New Zealand and globally. The effectiveness of these tools is crucial for protecting overall biodiversity due to the large proportion of land being privately owned in New Zealand (70%) and the small amount that is protected. Local or central governments should push tools like certifications and legal covenants before trying to implement legislation to protect biodiversity on privately owned land. Land owners tend to be much more responsive to cooperative measures rather than forceful measures (M. Giller [QEII] pers. Com., June 24th). Encouraging voluntary protection from land owners is a crucial aspect of protecting overall biodiversity in New Zealand.

1.1.7 Biodiversity / biological Indicators

Due to the complexity of ecosystems, monitoring programs may utilise biological indicators that are used as a measurable variable that indicates the presence or condition of phenomena that cannot be directly measured (Thomas, 1972). Indicators must reflect the presence or condition of any of the components within that environment and also be able to reflect the

magnitude of any change in condition that may occur (Froude, 1998). It is possible to integrate several indicators into an index where necessary to measure more complex systems (Thomas, 1972). Indicators can consist of cells, tissues, organs or whole organisms including single celled organisms to plants and animals (Spellerberg, 1991). Using indicators can make monitoring programs more efficient while still retaining detailed information content. The use of indicator species to monitor vegetation condition holds considerable promise for both production and conservation through identifying and alerting land managers to major changes within the ecosystem. The interpretation of vegetation condition data will allow the appropriateness of current management to be assessed, and corrective action to be taken if needed (Gibson & Bosch, 1996).

The presence or absence of an indicator from a particular ecosystem may be an indication of its current state or health. Monitoring presence and absence does not necessarily have to be individuals; it can also include entire communities of the indicator species, which is useful when monitoring expansive variables like ground condition or water condition (Spellerberg, 1991). The behaviour and physiology of an indicator can also be monitored to determine environmental conditions. An example of monitoring behaviour would be recording which birds are present at the dawn chorus and a more complex example of physiological monitoring could be measuring the digestion or cardiac activity of a particular species (Spellerberg, 1991).

Biological indicators can be excellent detectors of pollutants, as many are selected due to their intolerance towards pollutants and polluted habitats. Sentinels, detector, accumulator, exploitive and bioassays are commonly used for pollution monitoring (Spellerberg, 1991). Indicators are useful for vegetation monitoring also as monitoring can be simplified by avoiding species which are reacting mostly to other influences, and the abundance of species can be interpreted in a meaningful way for assessing the influence of previous management decisions (Gibson & Bosch, 1996). Palatable species are more likely to be affected by grazing in covenants and therefore make good indicators in covenants (M. Giller [QEII] pers. Com., June 24th). Examples of commonly used national indicator species in New Zealand can be found in (table 1).

Table 1: Selection of native species used as indicators of the distribution of selected native plants and animals in New Zealand

Name	What is it?	Why is it an indicator?
Lesser short-tailed bat/ pekapeka (<i>Mystacina tuberculata</i>)	Endemic bat.	Shows the general health and structure of forested ecosystems in many parts of New Zealand
Kiwi (<i>Apteryx</i> spp.) (five spp.)	Endemic, flightless bird	A good indicator of the abundance of key mammalian predators in a range of forest types in many parts of the country
Kaka (<i>Nestor Meridionalis</i>)	Endemic forest parrot	A good indicator of possum and stoat abundance in a range of forest types throughout the country
Kokako (<i>Callaeas cinerea</i>)	Endemic wattlebird	An indicator of rat and possum densities in North Island forests. The kokako, because of its sensitivity only exists on managed sites.
Mohua/yellowhead (<i>Mohoua ochrocephala</i>)	Endemic insectivorous forest bird	A very sensitive indicator of rat and stoat densities in South Island Beech forest.
Wrybill/ngutu pare (<i>Anarhynchus frontalis</i>)	Endemic shorebird that is highly specialised for breeding in braided river systems	These birds depend on South Island braided rivers for their breeding habitat and provide a good indicator of various threats degrading this ecosystem, such as pest predators and direct human impact, including water extraction and four-wheel-drive activities.
Dactylanthus/pua o te reinga (<i>Dactylanthus taylorii</i>)	Endemic parasitic flowering plant	Indicates aspects of forest health in parts of the North Island, including densities of introduced browsers, presence of native pollinators, seed dispersers and host trees.

(MfE, 2007)

There are limitations to using biological indicators, which should be noted when incorporating them into a monitoring program. The populations of many species can vary from the next and each population may tolerate slightly different environments. Technology may also make monitoring certain variables cheaper and more efficient than using biological indicators. Some indicators do not provide enough information to determine the state of an ecosystem at the community or habitat level (Froude, 1998). Collecting information on the health status of an

ecosystem may also be difficult using some indicators (MfE, 2007). The effectiveness of a biological indicator in a monitoring program depends on the situation, the ecosystem being monitored and the indicator being used. Where the presence or absence of rare or unusual plants may be important, as in conservation studies or inventory compilation, a more detailed examination of floristic composition may be needed (Gibson & Bosch, 1996).

1.1.8 Covenants and industry certification

1.1.8.1 An introduction to covenants

Open space covenants are a legal device originating from English common law, used voluntarily for long-term protection of desirable natural features on private land (Donahue, 2003). As noted earlier the amount of private land being protected for nature conservation in New Zealand has been increasing dramatically over past few years, which is in part due to the success of agencies like the Queen Elizabeth II Trust (QEII), which arose from the Queen Elizabeth the Second National Trust Act of 1977 (QEII trust act). This act was established to promote protection, preservation and enhancement of private land for the benefit of New Zealand. Open space covenant are the primary legal tool for biodiversity protection on private land in New Zealand.

Open space or conservation covenants have received very little attention internationally and even less in New Zealand literature (Donahue, 2003; Saunders, 1996), which has also been a similar case with literature discussing biodiversity protection on private land in general (Norton, 2000, 2001). The QEII covenanting process is generally conducted on a voluntary basis, where in most cases the potential covenanters approach QEII to begin the consultation process. Although this is a somewhat passive method for encouraging biodiversity protection on private land, it works well with the majority of land owners (M. Giller [QEII] pers. Com., June 24th). A survey of covenanters in the Canterbury region revealed that the majority of land owners place a covenant on their property for altruistic reasons (Saunders, 1996). Many land owners feel as though they are stewards of their land and have a vested interest in preserving any native biodiversity values present on it. A QEII open space covenant is an ideal tool for land owners to protect biodiversity values on their land in perpetuity. By using an open space covenant land owners may still have the option to use the area for economic use (grazing) if it is seen as appropriate by both parties.

QEII helps private land owners to protect significant natural and cultural values by providing a legally binding agreement in the form of an open space covenant. Open space covenants are

almost always placed on the land in perpetuity. Although there are varied term covenants available that can be applied for on a case by case basis. Shorter-term covenants include:

- Kawenata, on Maori land, which recognises tino rangatiratanga;
- Life of the Trees where individual trees occur in a situation where they may not be self-regenerating;
- Landscape protection agreements where the land does not have title, such as roadside areas.

(QE II National Trust, 2008)

Once a covenant has been established the local QEII field representative will conduct a formal baseline survey to determine what values are present and determine what fencing option would be most suitable. Funding can be applied for but much of the funding available in Canterbury is dispersed between organisations and is often limited to tight application windows. One funding pool of \$250,000 can only be applied for within a several week period every 3 years, which makes gaining funding for new covenant in between very difficult (M. Giller [QEII] pers. Com., June 24th).

QEII is comprised of a wide variety of experts in various fields that add knowledge and experience in fields such as land management, ecology, economics and agriculture. Management plans can incorporate a wide variety of land management tools to create an effective and cost efficient strategy for each property. QEII monitoring frameworks are set out in monitoring reports that are filled out by representatives (see appendices 1-4). The local field representative conducts biennial monitoring of each covenanted property. This is seen as a valuable time to catch up with land owners to see how things are going and whether there are any issues with covenant etc... Because monitoring is conducted biennially it is important that it is detailed, accurate, cost effective and well set up. This is where a solid management plan that has detailed aims and objective for monitoring is required.

For almost all covenants effectively protecting the values present involves fencing (exclosure) to remove grazing pressures from stock and some wild fauna. The costs involved with fencing off a covenanted area depends on the level of fencing that is required, the type of land that the fence is being constructed on and of course the size of the area that is to be covenanted (guides are available through QEII). The area of a covenant may be slightly offset to incorporate existing fencing and reduce costs. QEII will match the contribution of the owner for fencing requirements. Although this is a generous contribution QEII should not be seen funding organisation, due to the minimal resources they available.

There are currently 2813 registered covenants and 622 approved covenants, with a total protected area of 106 075ha and an average size of 30.9ha per covenant (QE II National Trust,

2008). These covenants encompass a wide variety of ecosystems and biodiversity. Each covenant's location in relation with LENZ's threat categories can be seen in (figure 3), and with regards to this study it is important to note the distinct lack of covenants in the acutely threatened primary forest on the lowland area of the Canterbury plains. The Canterbury plains have the lowest percentage of indigenous vegetation cover compared to other significant areas in the South Island, with approximately only 0-10% indigenous cover remaining and what is left remains acutely threatened (Rutledge *et al.*, 2004; Walker *et al.*, 2006). Remnants of primary lowland forest in this region are practically limited to Riccarton Bush, due to the high productive potential of land in the Canterbury Plains. Many covenants in this area are comprised of tussock/shrublands (see chapter 3). The total area of land under the Canterbury regional council is the largest in New Zealand with 4 220 000ha. As at the 31st of March 2008 there were 220 registered and approved covenants in this region with a total protected area of 12 386ha and an average covenant size of 56.3ha (QE II National Trust, 2008).

There are a number of benefits for placing an open space covenant on land including the benefit to New Zealand's unique native biodiversity. Approximately 70% or 19,000,000ha of New Zealand is privately owned, and the importance of biodiversity protection on private land has been well represented in literature (Norton, 2001; Norton & Miller, 2000; Norton & Roper-Lindsay, 2004). The majority of acutely threatened ecosystems occur on highly productive lowland areas, which are generally privately owned. These areas are often small, but are still crucial to preserving lowland remnants. QEII open space covenants can also cover cultural values which help to preserve our rich cultural heritage. (Saunders, 1996) states that covenants only force land owners to give up rights to their land with little or no compensation and recommend that they are best suited to large commercial holdings with little management input. The other side of this argument is that the land remains under a land manager who knows the land intimately and will have a high management input and in some cases the land can still be used for economic gain.

One of the key successes and also major problems with QEII's current structure is the reliance on existing staff members and field representatives. Each field representative builds a rapport with land owners and works through the process personally with them. Management plans can be transferred to another representative or land owner, but they need to be detailed, structured and include clear monitoring objectives and be easily replicated. If a representative conducts monitoring at their own discretion (visually) it may not be possible for any repeat monitoring and especially not by another observer.

Legal protection in perpetuity means that the covenant will remain binding even if there is a change in land ownership. Adherence to terms and conditions from change of ownership is seen as a potential problem. To date changes of ownership have not been a major issue for QEII with approximately 50% of covenanted properties having changed hands at least one

time and there have been no substantial issues noted with compliance of covenant conditions on these properties (QE II National Trust, 2008). During the financial year of 2007/08 adherence to covenant terms and conditions was high. 73.5% of covenanters were seen to be adhering to their covenants terms and conditions at a level that exceeded the expectations of QEII. A further 21.7% were seen as adhering to their covenants terms and conditions satisfactorily and only 4.8% were seen as poorly adhering their terms and conditions (QE II National Trust, 2008). The canopy condition, which varies significantly with each type of covenant and the values present, was assessed and 71.7% of covenants had a 'good' canopy condition. 25.5% of covenants had a 'fair' canopy condition and 2.8% were seen to have poor a poor canopy condition (QE II National Trust, 2008). These statistics show that although the QEII covenant process is relatively passive, it seems to work well with land owners and managers. These statistics were collated on a per covenant basis and do not include ecosystem types or threatened ecosystems in the analysis. More detailed information would be required to assess how successful covenants are or have been at protecting biodiversity values (see chapter 5).

Registered and Approved QEII Covenants

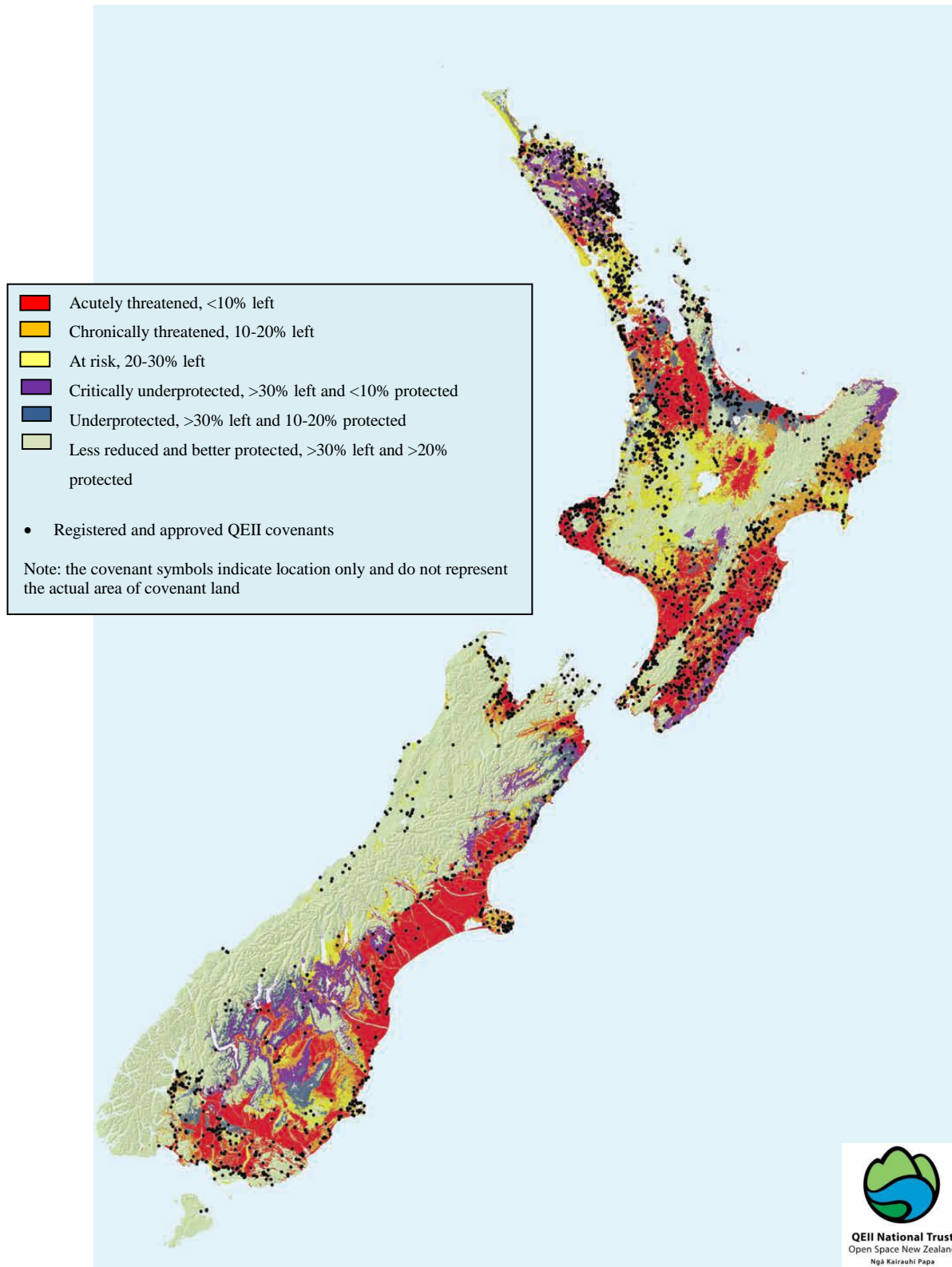


Figure 3: Location of registered and approved QEII covenants and their location within Land Research Threatened Environments Map as at 30th June 2008 (QEII National Trust, 2008).

1.1.8.2 An introduction to industry certification

Sustainable farming is becoming increasingly popular as growing public environmental awareness is driving legislation and markets to adopt more sustainable products. There is a wide range of definitions of sustainable products the broad idea is that a product is produced in a way that is less detrimental to the environment. For some products life cycle analysis may be used to determine the sustainability of the product from production to disposal. Industry certifications are becoming more desirable to both producers and consumers, because they certify that a property is managed in a sustainable manner. Industry certifications are designed to promote more sustainable practices in industry operations. Certifications are common in forestry because of the awareness of problems created by illegal logging and deforestation (Kiker & Putz, 1997). There are a number of certifications available that provide increased quality control for products, but the key certification systems for providing biodiversity protection in New Zealand are the Linking Environment and Farming (LEAF) Marque system and the Forest Stewardship Council (FSC) systems. This thesis will focus only on agricultural practices and will investigate the LEAF Marque certification.

The standards set out by LEAF Marque, like many other certifications apply to the entire property of an operation and not only the aspects involved with the production of the certified goods (LEAF, 2008b). It involves implementing strategies and guidelines that provide both industry and consumers with benefits. The industry benefits through improved market access and improved product image, which leads to improved consumer confidence. LEAF Marque is a United Kingdom (UK) based organisation and is an internationally recognised standard. It aims to provide assurance that products are being produced sustainably now and in the future (LEAF, 2008a). Improved market access is gained by having access to stores that only stock certified producers, which can give producers a competitive advantage. Consumers benefit by knowing they have purchased quality goods that have been produced responsibly and more sustainably. They also have better awareness of how their products are being produced and how sustainable the production methods are.

LEAF Marque utilises a technical advisory group that includes organisations from all sectors of agriculture and horticulture (LEAF, 2008b). These organisations provide input into the standards and guidelines set out in the global standards. Biodiversity protection measures are considered in this certification through a number of guidelines. This certification includes a broad section on wildlife and landscape values for the property. Standard 6.1 of the LEAF Marque Global Standard 2008, states that “a land manager must conduct a conservation audit of their property, with the purpose of avoiding the risk of environmental damage or deterioration.” It also states that “approved producers must be able to demonstrate an awareness of the distribution of the key wildlife habitats, important species, other valuable

environmental and archaeological or historical features on their farms as listed in the guidance notes, and know the farming operations that could damage or have a detrimental effect on them (LEAF, 2008b).” In total there are 27 standards that relate specifically to the environment and landscape effects of the property and a number of more general clauses that relate to the preservation of the environment on certified properties.

While the 2008 standard includes a number of standards to improve the environment and biodiversity on the certified properties, it does not include any considerable information on monitoring. While LEAF Marque does recommend that land managers contact local organisations to help improve environmental monitoring, they do not include any of their own standards or advice for monitoring procedures. Setting up a detailed monitoring program should be an important aspect of biodiversity protection through certification. Being aware of potential risks to the environment and minimising them is a good first step, but it is not sure whether biodiversity values are being sustained into the future.

2 Chapter two – Review of monitoring methods for measuring vegetation change in tussock shrubland areas in New Zealand

This chapter will examine the range of methods currently used to monitor vegetation change in tussock shrublands in New Zealand. All of the covenants used as case studies in this research are comprised of tussock shrubland ecosystems. For the purposes of this research tussock shrublands are defined as ecosystems that are comprised mainly of tussock grasses and/or low shrubs (generally woody stemmed vegetation < 2m tall). Each method will be described including its efficiency, resources required, expertise required and where possible cost effectiveness. By ensuring that monitoring is providing effective and efficient feedback on vegetation change, land managers will have accurate information to analyse and improve current management regimes. Having a successful and complete feedback loop is crucial for the ongoing success of biodiversity protection on private land under ongoing economic use. It is important that monitoring methods are suited to the objectives of the land management both economically and ecologically. As well as assessing the cost effectiveness and information content of each method for use on privately protected land, the monitoring frameworks from QEII covenants and LEAF Marque certifications will be assessed.

It is crucial that the objectives of a monitoring programme are clearly defined before monitoring begins and even before the monitoring methods are selected. These monitoring goals and objectives will be determined by the objectives of the management plan and the resources available. This will ensure that an appropriate balance between gaining detailed and accurate data and the limitations of the available resources is obtained with regards to monitoring. If no monitoring objectives are set out for the monitoring program then the chances of it failing are much higher and the resources involved will be wasted. The importance of developing sound monitoring goals and objectives is discussed in depth in Chapter 4.

It is much more difficult monitoring tussock and shrublands than it is to monitor forested communities. Scott (1965) has identified three main reasons for this. The first is due to the spatial distribution of tussock plants, with small plants usually being close to large plants. The second is due to the variation of the canopy spread at different levels within the vegetation. The third is the fact that these ecosystems are often located on steep slopes that have a lower production potential (Scott, 1965), which means that access to and movement around the sites is likely to be more difficult than for gradual sites.

2.1 Introduction to monitoring for industry certification and for QEII covenants

When monitoring biodiversity it is certainly not possible to record everything and anything in an ecosystem, so the use of samples is necessary to create smaller, more easily measurable areas. In these sample areas it becomes possible to record most, if not all species present, while still maintaining an accurate view of the entire site (Clarke, 1986). Samples need to be allocated at random within the study site to provide statistical power for data analysis. For successful monitoring it is essential to position samples accurately in the field and to be able to readily relocate them for future measurement. This involves permanently marking the sites with stakes (usually metal) and recording their location with a GPS unit (if available).

The key variable and the focus of this thesis is monitoring vegetation in response to management decisions (pest control, grazing etc). Within the chosen monitoring sites, temporal variation of the desired variables needs to be measured by an appropriate method. Variation due to factors like the following must also be acknowledged as they can create 'noise' in the results:

- Seasonal effects
- Long term directional trend of the ecosystem
- Climate change
- Natural cycles

(Goldsmith, 1991)

Monitoring is one component of an effective property management cycle which includes all aspects of the farming system (see figure 4). It provides a means to assess how vegetation is responding to management strategies. Results from scientific studies also provide an important input towards building a successful management plan. Results on the outcomes of scientific studies can provide feedback on monitoring methods for particular ecosystems.

In most cases for both industry certification and covenants an initial monitoring survey is conducted to ascertain what values are present on the property. Identifying species that are more acutely threatened is not only beneficial for biodiversity preservation, but it can also make securing funding for setting up any necessary exclosures easier. Initial monitoring surveys provide good detailed information that can be used for developing goals and objectives for the properties. Ongoing monitoring or auditing is required thereafter to ensure that the goals are being met and values are being sustained. Being able to identify species quickly and accurately is an important skill for observers. The accuracy of the monitoring program will depend on the accuracy that the observer has at identifying species. Botanical

and ecological knowledge and experience will help to greatly improve the accuracy of monitoring program.



Figure 4: Relationships between the different elements of farm management planning (Norton, 2008).

With certification the land manager is usually required to conduct ongoing monitoring and then an auditor can check the results of the monitoring. Some cases may require the auditor to conduct monitoring themselves, but in most cases their role is to check monitoring results and systems to ensure they are appropriate. In this situation it is crucial that the management and monitoring plans are detailed and that the correct monitoring procedures have been implemented. They need to be easily replicated and the individual conducting the monitoring has to have the necessary expertise.

Although the systems used for monitoring can vary between certifications and between covenants, they all require the monitoring to be accurate, efficient and easily repeatable (by another observer if necessary). Having limited resources for monitoring is common so cost-efficiency is the key criteria. Possibly the biggest issue with long term monitoring is that it can have a high demand on resources so it needs to be properly targeted to (1) ensure that it provided good and relevant information and (2) that it can be repeated effectively.

The amount of biodiversity monitoring that occurs in order to comply with an industry certification scheme varies with each certification. A large proportion of certifications do not apply any stringent conditions to specifically protect biodiversity, but focus more on general farming practices and animal welfare. Some require little attention to biodiversity protection

on the property but urge land managers to ‘consider’ the environment while conducting normal land management practices. Forest Stewards Council (FSC) and Linking Environment and Farming (LEAF Marque) certification systems include environmental and biodiversity protection conditions that must be met if they certification is to be gained. Although FSC is not relevant to this research as forestry is not in the scope of ongoing economic use on rural land as determined in this research. LEAF Marque is a certification system developed in the United Kingdom (UK), but is utilised internationally. It is designed to create a link between environmental sustainable outcomes and economically productive processes (LEAF, 2008a). FSC and LEAF schemes do not specify what they believe is acceptable as an accurate monitoring scheme, but with both of these organisations there is a very strong expectation that the land manager will have appropriate monitoring systems in place already.

Monitoring in QEII covenants is conducted by the regional field representative biennially, unless otherwise stated. QEII monitoring follows a broad structure set out by QEII (appendix 3), but it is the responsibility of the representative to gather the information. In the Canterbury region this generally consists of visual (walk through) methods, so that the representative can get a good look around the covenant. This involves assessing overall condition, which includes physical condition (fences etc) as well as biodiversity condition. Photo points have also been set up on many of the covenants, some of which are general and others for more specific vegetation monitoring. QEII also see these visits are an opportunity to meet with landowners and discuss how the covenant is being managed. Meeting with land owners provides a good chance to discuss the current and future management of the covenant.

2.2 Statistics, analysis and data storage

Monitoring must obtain data that is both accurate and analysed correctly, as a failure to do so may cause a failure in the entire monitoring program (Legg & Nagy, 2006). Analysis however needs to be simple and effective as the land owners and or representatives may not have the statistical skills necessary to analyse complex data sets to determine monitoring outcomes. Data and analysis needs to be simple, effective and informative. Analysis described in (Allan *et al.*, 1998) uses a simple to use computer program that automatically plots the monitoring data gained from needlepoint monitoring into a readable output. (Scott, 1989) states that one of the benefits of visually ranking vegetation is that results are presented in a way that is similar to the way in which people will converse about vegetation. Photopoints provide a visual measure of vegetation change which is easily interpreted, but if photographs are ranked at a later date then the data needs to be easily interpreted. The reasons stated above are why these methods are more suited to monitoring in these situations.

Data needs to be stored where it is easily accessible for comparison with future data. QEII is currently developing a national data base for the location of photopoints within covenant sites. This could also be extended to include monitoring data if necessary. Industry certifications rely on the land manager storing the information themselves and then having it available for auditing when required. If a photographic method is used then images need to be named or tagged with as much information as possible so that images are not confused when a comparison is being made. QEII have the potential to incorporate information they gather on private land and incorporate it into a national data bank like the one described by (Wiser *et al.*, 2001). This would further the knowledge presently available on overall biodiversity condition nationwide.

2.3 Monitoring Methods

The methods reviewed in this research are similar techniques to those used in a review conducted by Allen (1993), which include the use of photographs, plot/transects, quadrants, biomass, tagged plants and height frequency measurements. Each of the methods mentioned above is suitable for recording vegetation change, but the scientific validity of data recorded from each method can vary greatly according to the objectives of the monitoring (Allen, 1993a). Remote sensing, visual rank and needle point methods will also be reviewed. There have been a number of larger scale technological advances with data measurement methods and equipment, which has lead to an improved suitability of using remote sensing for monitoring vegetation in smaller areas.

Various factors interact and affect the way stock graze within a block. These include grazing and stock movement patterns, shelter from bad weather, warmth of slopes, access to water (especially if limited), previous burn patterns, animal habits and congregation patterns, as well as size and shape and topography within the block. Monitoring needs to be sensitive to change in these more heavily grazed areas. If these factors were better understood for each site monitoring could be more intensive in specific areas or sectors of the covenant and more general or cost effective in others.

Generic equipment required for all vegetation monitoring methods is listed in (table 2). Further equipment specific to individual methods detailed below is included in separate individual tables.

Table 2: General recommended equipment for vegetation monitoring. Please note that it is assumed that for all methods the observer will have a field notebook. Camera and GPS are also essential for recording and relocating samples for all methods

Item	Use
Topographical map	
Aerial photo	Of the specific site to be monitored
Pen, pencil, rubber, clipboard	
Spirit-based felt tip pen & red chinagraph pencil (for use on aerial photographs)	Allows the recorder to mark monitoring sites on the image
Plot sheets	Will vary between organisations, individuals and methods, but should have identical information for each site
Compass, altimeter and clinometer	
Stakes	Size and type will depend on method, but are always handy to have in case anything needs to be permanently marked.
Measuring tapes	
Camera	Preferably digital as it is easier to store, upload, view, discard and manage images.
Plastic bags and labels	In case samples need to be taken from the field and identified
Small blackboard or whiteboard	For recording site information that is visible in images
GPS unit	For quickly recording and locating monitoring sites or sites of specific interest

(Wiser & Rose, 1997)

The methods to be reviewed in this thesis are the most commonly used methods for monitoring tussock grassland and shrubland communities in New Zealand. It should be noted that many of these methods can be used in conjunction with other monitoring methods. Utilising a variety of methods to measure different objectives is crucial for a well constructed monitoring programme.

These methods are as follows:

- Subjective methods
 - Walk through (visual)
 - Photopoints
- Objective methods
 - Height frequencies
 - Transects
 - Quadrat
 - Tagged plants
 - Biomass

- Needle point
- Remote sensing

To clearly define how these methods fit into a monitoring programme they will be set out into the following:

- A. Methods used for locating sample units &
- B. Methods used for measuring vegetation within sample units

Some methods fall in between categories as they locate the sample and enable the vegetation to be measured. Methods have been grouped broadly.

2.3.1 Methods for locating samples within a site

2.3.1.1 *Transects*

Transects are used in vegetation monitoring programs as a well defined and repeatable method for measuring vegetation change. Once transects have been established within a site other monitoring methods (see 2.3.2) are then used to monitor the vegetation. They have been used by a variety of studies in tussock grassland ecosystems, including studies of invasive species (Cuff, 1991; Harris & Mark, 1991) and burning (Duggan, 1991). The transect method primarily provides a line of well defined areas or quadrats along a straight line or ‘transect’ (Reay & Norton, 1999). Transects should be permanently marked with steel standards or fibreglass rods at the beginning and end, so that they are easily located to allow for future repetition. The samples (quadrats) along each transect can be permanently marked, but it may be more appropriate for the observer to carry the rectangle or grid into the field with them each time. This ensures that monitoring using transects is easily and accurately repeated transect to transect and observer to observer for future monitoring (Scott *et al.*, 1988).

By monitoring an area using transects it is possible to obtain an accurate measure of vegetation change along a gradient, whether it be inter or intra vegetation variation (Daniel & Rasmussen, 1985). This is of particular benefit for monitoring sites that are grazed, because it is possible to determine vegetation change in response to grazing intensity, type and seasonality. Taking small measures within identical sample sizes allows the estimation bias to remain constant throughout the monitoring process (Clarke, 1986), which allows for improved accuracy in the method.

Temporal changes in vegetation groundcover classes, species frequency, species density, species size, species rank and biomass can be accurately assessed in response to changes in

management activities using transects (Clarke, 1986; Scott, 1993; Wardle & Fahey, 2002). The number of transects for each property will depend on the range of environments present and the size of the area to be monitored. Transects should represent the full range of environments present on the property to gain an accurate overall view of biodiversity condition. This means transects should represent and contrast ecosystem types, the level/intensity of grazing, areas that have been previously burnt if applicable and even land tenure if applicable (Duncan *et al.*, 2001). Individual transects can vary in length depending on the study or management goals of the area being monitored. For shrubland areas, transects of 50m² to 100m² are seen as an ideal size, with sides at a ratio of 1:5 or 1:10 (Clarke, 1986). Length commonly ranges between 100m (Cuff, 1991; Duggan, 1991; Duncan *et al.*, 2001) to 300m (Scott, 1993; Scott *et al.*, 1988) for shrubland areas. Each transect is divided up at defined intervals into sampling distances, which will vary with the length of the transect and size of the site.

If there is a large variation in the size of the vegetation like an area of Kanuka shrubland with herbs and mosses present in the understory, nested transects could be utilised. This is where you use a large volume transect for the larger vegetation and then have randomly located ‘nested’ (smaller transects) within the larger ones to more accurately measure the smaller species present. Once a transect is set up permanently then this method does not require much equipment apart from any equipment needed for measuring vegetation. Most New Zealand studies follow a similar method to that used in (New Zealand Institute of Agricultural Science. & University of Canterbury. Dept. of Botany., 1963), where a square quadrat with a smaller grid inside is used to determine which plants get recorded (Wiser *et al.*, 2001). Other studies have used variations like a quadrat with needles pointing inwards to determine which species are recorded at each site (Scott *et al.*, 1988).

This method has been successfully utilised for other types of monitoring including our native fauna. Transects have been used in New Zealand to monitor our native avian species (O'Donnell, 1996, 2000; O'Donnell & Langton, 2003) and to monitor invertebrates (Bell *et al.*, 2005; Reay & Norton, 1999). Transects are easily integrated into vegetation monitoring programs that use other monitoring methods. Special equipment required can be found in (table 3).

Table 3: Special equipment required for transect monitoring

Equipment	Use
Metal standards	For permanently marking monitoring sites and for locating the sites more easily. Two larger stakes for either end and smaller stakes to ensure the transect is straight.
Cord (must be at least the length of the transect)	For lining up the two standards, making it easier to follow the transect line more accurately

2.3.2 Methods for measuring vegetation

Objective methods generally have high information content and accuracy, but require more resources, whether that is equipment, labour or time. They are often used for scientific research and detailed studies on smaller sites. Permanent plots are considered a robust way to measure vegetation change whether that is general or in response to a management activity (Wiser & Rose, 1997). A wide range of New Zealand tussock shrubland studies have utilised permanent plots for monitoring and have found that they provide valuable information on vegetation change. Drawbacks include the costs involved with setting up, maintaining and measuring permanent plots.

2.3.2.1 *Visual rank methods*

Visual methods are difficult because there is only a small quantity of literature written about them and there can also be confusion over what method is actually being used. Visual monitoring is the primary method used by QEII representatives in the Canterbury region, but it is not a structured method as described by (Scott, 1989). The former is ‘generalised’ monitoring of a site by walking around it and observing what is occurring and the state of the site and will be referred to as informal visual monitoring. The latter is a scientifically valid method that still ranks species visually, but will allow for accurate assessment of vegetation change in response to a management practice and repeatability by using samples. This method will be referred to as formal visual monitoring.

Informal visual monitoring can still be a very useful method for determining processes occurring within a site if the observer is knowledgeable and experienced. They should be able to identify a range of processes occurring in these ecosystems. This may involve looking at what vegetation is present, how the vegetation has been grazed, what browsing is occurring, what kind of animal droppings are present etc. This kind of monitoring relies on the knowledge, experience and opinion of the observer to record what they see and its abundance or condition within the site. A walk through allows the land manager or field representative to gain a good overall view of an area relatively quickly, it also allows them to assess a range of factors like fencing condition or invasive species. There is the possibility for pest management to be conducted while the land manager or representative is conducting monitoring around the property. When a method like this is used the accuracy depends primarily on the knowledge and experience of the observer. If no permanent plots or sampling techniques are used then repeating the monitoring is not possible.

A common problem with visual methods in tussock grasslands is that the bottom grasses and in particular mosses and herbs are often overlooked (New Zealand Institute of Agricultural Science. & University of Canterbury. Dept. of Botany., 1963). For these reasons this method should only be used when a high degree of accuracy is not required. Monitoring vegetation change in response to a change in management practice would be difficult because it would rely on the observer's memory of its previous condition. The main purpose of visual monitoring methods is for the observer to have a good look at what is occurring within an area relatively quickly.

Visual rank methods have been used in studies to describe vegetation successfully using a more scientific method described by (Scott, 1989). This involves locating samples and ranking the species abundance (rank) visually, which allows for future repetition and also gives more structure to the monitoring than informal visual monitoring. Samples can be located using various methods including permanent plots (quadrats, transects) or plotless methods.

Vegetation trends can be measured over time, by comparing the shift in the composition of certain species. Although it would seem that there would be inconsistencies between observers, (Scott, 1989) states that most variation (65 – 90%) comes from variation in vegetation composition between quadrats and 10 – 30% of variation is due to observer and other sources. Monitoring using this technique can be easily integrated into an existing monitoring program where permanent plots have been set up.

Scott (1989) states that this method is attractive because it corresponds closely to the way people describe vegetation in conversation by listing species in order of importance. Another attraction is that it is generally easier to estimate the difference in abundance between species, and hence their rank, than to estimate absolute levels of each. These methods also require fewer resources than more intensive methods (height-frequency, tagged plants, biomass etc) and can be conducted more quickly. In a study by (Bråkenhielm & Qinghong, 1995) monitoring using visual estimates took approximately 6 minutes per quadrat, compared to 8.5 minutes for point frequency methods. (Bråkenhielm & Qinghong, 1995) also found that using visual estimates was the most accurate, the most precise and the most sensitive method when compared with point frequencies and subplot frequencies (quadrats divided into smaller samples). Although they also state that inter person error was greater when using visual estimates with smaller and wide spread plants. Another study by (Carlsson *et al.*, 2005) states that visual estimates were more suited to situations where a high level of accuracy was not required, but time efficiency is important. There is no special equipment required for this method.

2.3.2.2 *Photo points*

Photo points are a low cost, easily repeatable monitoring method that can be used effectively to assess the change in vegetation cover and ecosystems in response to land management activities and objectives with time (see figure 5). Measuring vegetation change in response to grazing is crucial to ensure that biodiversity values are being sustained. Monitoring using photo points is useful for a wide range of sites including private and conservation lands. This is due to the large area of land that can be ‘summarised’ with one image and easily compared to previous or future images. Photopoint monitoring can be used effectively on any land tenure and can provide good information on vegetation change with or without grazing. This method of monitoring has been used in a wide range of studies in New Zealand and is probably one of the most versatile.



Figure 5: Panorama view of Douglas fir spreading near Queenstown from 1985 (left) to 2003 (right) (Norton, 2006)

Photo point monitoring consists of obtaining photographs of an identical area, so that they can be analysed and compared with previous or future photographs. Analysis comprises subjective assessments of changes in the photos through time (e.g., changes in the cover of particular species). It is important that the site for each photo point is accurately marked out, so that it can be easily and accurately replicated by the observer or another person. There are three major components of photo point monitoring. Firstly the photopoint and scene must be clearly defined so that it is easily repeated. Secondly photos should be taken at a similar time of day in similar weather conditions and in the same season where possible. Finally, the data needs to be recorded, organised and filed for further analysis (Hall, 2002). If these steps are conducted accurately then an effective record of change can be obtained relatively easily.

Elements that are present on the property that best reflect these objectives need to be identified. These elements should be incorporated in or be the focus of the photo point scenes. There must also be an adequate number of photo points to cover all of the objectives and all of

the required environments (usually 15-30 per property). The total number of photo points will be an indication of the range and diversity of ecosystems present on a property (Norton, 2006). Photographs provide an excellent tool for educating the public and providing stimulation or encouragement for projects. It provides a visual measure of the progress being made.

When establishing photo points it is important to ensure that the scene will adequately document expected changes. Different types of photo points can be used to assess different aspects of a property. For instance if it is necessary to assess the overall condition of a property then wide angled panorama photo graphs taken of an entire valley or hillside would be ideal. It is important when setting up panoramic photo points that they will not be blocked by vegetation in the foreseeable future. For these images the scene may be set by natural features, rather than stakes or tags, due to the large scale (Norton, 2006). It is important to utilise natural features like ridge lines and not vegetation because the vegetation can change quite rapidly. It may be helpful if a photo point is selected where multiple images can be taken, especially with large scenes or if the location is difficult to access. If GPS is available, recording the location of the site initially would make locating it in the future much easier.

Taking a photograph of specific areas within a management zone would be beneficial to observe species composition, bare ground or litter for that site. If a specific area is to be measured then a more precise short range photo can be taken where the vegetation composition can be defined. For these images it will be necessary to set out the scene with two stakes or markers 25m apart (Norton, 2006). This way the stake at the other end can become the focal point for the image. It is important to clearly define the scene so that it will remain identifiable even if the vegetation spreads and grows significantly. The photopoint must be set up so that it will not be obstructed if the vegetation changes rapidly in the future. Laying out a 2x20m grid with 2x2m quadrants between each stake and taking a photo from each end will help with scale and analysis (see figure 6) (Norton, 2006). These images can be combined with quantitative measurements of vegetation taken in the field where necessary. Images can be uploaded to a computer and analysed (scored) digitally at a later date (Norton, 2006). To use this variant the grid needs to be used when taking the photo, so that scale can be seen.



Figure 6: Photopoint photograph taken at Glenmore Station

Spot photos can be used to monitoring single plants and or ground cover plants. They are taken directly over the vegetation at a set height with markers (could be a quadrat) so that the image scale remains constant, which allows comparison between images over time (see figure 7). Spot photos are only suitable if the vegetation is shorter than 0.5m. If the vegetation is taller than 0.5m then a visual rank of vegetation cover would be more suitable (Wiser & Rose, 1997).

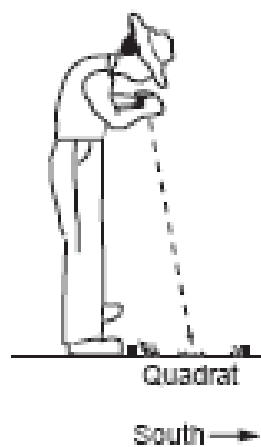


Figure 7: An illustration of an observer taking a spot photograph (Willigen & Grodecki, 2007)

Photo points are able to detect changes in vegetation cover resulting from changes in land management practices. They are a simple, low cost and easily repeatable method of assessing vegetation change. They utilise equipment that is readily available to most land managers and can be conducted by people with little or no expertise if setup correctly. The equipment required for photo points consists of gear that should be readily available to most land managers and field representatives. A camera (higher quality is better) is the most important piece of equipment for this method and tripod may be necessary (see table 4).

Table 4: Special equipment required for photopoint monitoring

Specific Equipment Required	Use
Camera (digital)	For taking the photographs
Tripod	For taking 'specific condition' photographs
Tags, stakes and markers	To permanently mark the site for future monitoring and to identify each photo point

2.3.2.3 *Quadrats*

Quadrats can be used to measure vegetation change in a range of environments from indigenous forests (Allen, 1993b) to tussock grasslands (Buxton *et al.*, 2001; Meurk *et al.*, 2002; Norton *et al.*, 2006; Walker *et al.*, 1995; Wiser & Rose, 1997). They are an ideal method to utilise when comparing different sites with different management regimes or treatments (Norton *et al.*, 2006). Quadrats are generally circular or square in shape and define the sample (normally range between 0.5m² - 75m²) that is to be monitored (Clarke, 1986). Unlike transect methods, where plots are located along a well defined line, this method uses quadrats that are randomly located throughout the study area. A good guide to this method is the Wraight 20 x 20m method described in Wiser and Rose (1997). Permanently marked quadrats are set up in the study site to monitor vegetation composition and change. Quadrats are marked with metal standards that can be painted in a high visibility colour and marked with the appropriate site information. Markers allow the sites to be easily located for future monitoring. Depending on the objectives of the monitoring, the quadrats may be set up in pairs to measure vegetation change in response to a change in management like grazing. If the objectives of the monitoring are to measure the effects of grazing then some of the sites may be setup with exclosures so that a direct comparison can be made (Buxton *et al.*, 2001; Rose & Frampton, 2007).

The size of each quadrat may differ depending on the type and composition of vegetation being monitored and how sparse the ground cover is. Ideally they should be small enough to

search and large enough to represent a range of vegetation. Studies in New Zealand have quadrats that can range between 0.5 m x 0.5 m (Walker *et al.*, 1995) and 75 x 75 m (Meurk *et al.*, 2002). (Wiser & Rose, 1997) recommends 20 m x 20 m plots as a manageable size for measuring most tussock grasslands. Plots may be located as a representative, stratified, or subjective sample of the study area (Allen, 1993b). Quadrats should be set up with the top edge perpendicular to the slope and the sides running parallel with the slope. Within each quadrat everything can be recorded or coordinates can be chosen as individual sites for measuring vegetation. This will depend on the size and number of quadrats being used in the study. Taking spot photos at each coordinate is one method that can be used (Wiser & Rose, 1997). Spot photos can be used and follow the same method as described in section (2.3.2.2).

Once the quadrat is setup correctly monitoring in the future can be repeated accurately and more easily. The speed at which an observer can monitor the quadrat determines how many quadrats can be completed while they are present in the field. If a larger number of quadrats can be used then the accuracy of the study will be increased (Goldsmith, 1991). (Wiser & Rose, 1997) states that three or four experienced observers can establish and measure a 20 x 20m plot in approximately 1-2 hours. Species frequency is the core value to be taken from this method, which can be gained by following a transect with a measuring ring, through the middle of the quadrat and measuring species frequency at set intervals within the ring (Wiser & Rose, 1997). Smaller subquadrats (similar to nested transects) can be placed within each quadrat to monitor smaller species like mosses and lichens if it is required from the objectives of the monitoring. Special equipment required can be found in (table 5).

Table 5: Special equipment required for quadrat monitoring

Equipment required	Use
Metal stakes	Marking out sites for accurate measurement and future site identification
Circular measuring ring	Measuring each individual site
Measuring tapes	Should be long enough to measure the length of each side and there should be enough for the four sides of the quadrat
Camera	Taking stereophotos
Rigid frame	Grid set to the desired size for monitoring

2.3.2.4 Needle Point

This method is much less documented in scientific studies than other methods reviewed. It has been endorsed as a practical method for monitoring in a Land Condition Monitoring manual

produced by Otago and Canterbury Regional Councils as well as Landcare Research and Rural Futures Trust as a practical monitoring method for land managers (Allan *et al.*, 1998). Needle point monitoring is an objective method that provides data on vegetation condition and is sensitive to vegetation change. This method is conducted by pushing a needle point wheel as used by (Tidmarsh & Havenga, 1955) in a straight line between two permanent stakes (see figure 8). These stakes should remain at the site to allow for future repetition of monitoring. As the wheel is pushed along the line, each time a point comes into contact with vegetation at the ground level (0-2cm); the first species that contact was made with is recorded (Allan *et al.*, 1998). For each site a minimum of 200 hits should be recorded, so that an accurate view of the vegetation composition for each site can be gained (Allan *et al.*, 1998; Gibson & Bosch, 1996). Although 500 hits have been used in some studies (Colhoun *et al.*, 1991). This depends on the size of the study site and the number of transects used as well as the intensity of the study.



Figure 8: Needle point measuring device (Allan *et al.*, 1998)

This method is designed to remove observer biases, by only recording species that come into contact with a needle point within the ground level zone. Although there can be biases when the observer decides which species to record (the first species hit or subsequent species) and also with the effect that the device has pushing tussock plants aside before the measuring zone is reached (Allan *et al.*, 1998). It is important to remove biases when monitoring vegetation, but it is especially important in tussock grasslands, due to the vegetation composition. The special equipment required for this method can be found in (table 6). There are variations of this method including the observer records the first species to come into contact with the end of their boot. Other variations may use slightly different measuring wheels or devices. The key for this method is to have as many ‘hits’ as possible.

Table 6: Special equipment required for monitoring using needle point methods

Equipment required	Use
Pin Wheel measuring wheel	Is the device used to locate which plants are to be measured / recorded

2.3.2.5 Point/height-frequencies

Point- intercept or height-frequency methods were designed to measure the vertical structure and composition of tussock grasslands (Wiser & Rose, 1997). This method gives information on the horizontal dispersion as well as the vertical composition of the vegetation, which is a key strength. In New Zealand the height-frequency method used is commonly based on the method described in (Scott, 1965). The method involves using a measuring device and recording what species intercept the sample volume or touch the device and their height (see figure 9). In the method described by (Scott, 1965) the device consisted of sampling rings attached to a rod: 5cm in diameter and 5cm apart, giving an overall volume of 100cm³. Measuring devices can vary depending on the study, but follow the same general concept. More recent study have used similar devices but have since slightly improved the measuring device by using open rectangles that do not displace the plants instead of the circular rings for taking measurements, but still maintain the 100cm³ volume (Dickinson *et al.*, 1992; Mark & Dickinson, 2003; Wiser & Rose, 1997). Another recent study used a 10 x 10 x 10cm device (Espie & Barratt, 2006).

For most areas taking 100 measurements along the length of the transect is seen as sufficient to get a good overall view of a tussock shrubland area (Dickinson *et al.*, 1992), but this will of course vary with the objectives of the study and size of the study area. The frequency of measurements and the length of the transect can vary, recent studies have ranged from 25m (Espie & Barratt, 2006) to 100m (Dickinson *et al.*, 1992; Mark & Dickinson, 2003). Data can also be collected along transects within quadrats, where locations or coordinates within the quadrat are used as measuring sites (Mark & Dickinson, 2003; Wiser & Rose, 1997).

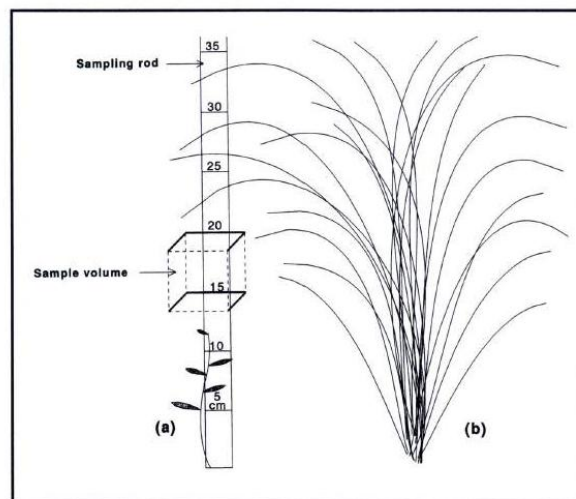


Figure 9: Measuring device for point - height frequency methods, showing the sample volume where vegetation that disrupts this volume will be recorded (Wiser & Rose, 1997).

Height frequencies monitoring provides high information content for the structure and floristic composition of both natural vegetation trends and changes from management influences, as it provides easily interpretable and statistically testable data (Grove *et al.*, 2002). This is beneficial for monitoring grazed vegetation as it provides detailed information on vegetation response to management changes, like grazing intensity, type and seasonality (Rogers, 1991). Once a detailed height-frequency monitoring program is established it provides an easily repeatable method for monitoring and describing representative samples of tussock communities (Grove *et al.*, 2002). (Wiser & Rose, 1997) state that this method is more effective than the Wraight quadrat method for measuring vegetation that is >1m in stature and that it is also more sensitive to subtle vegetation change in these ecosystems. However it is more labour intensive than other permanent plot methods (Espie & Barratt, 2006; Grove *et al.*, 2002; Wiser & Rose, 1997) and is seen as being more suited for intensive studies rather than broad scale monitoring. (Wiser & Rose, 1997) state that two experienced observers should be able to monitor a 50m transect in about 2 hours.

While this method is easily repeatable and provides high information content on vegetation change, it does require a degree of subjectivity from the observer. Observers must make a judgment on the plant boundary location at certain heights (Wiser & Rose, 1997), which can be very difficult in windy conditions. It is important to note that this method is only easily repeatable if the sampling areas (transects or quadrats) are permanently marked. Marking can be achieved with permanent metal stakes at each end of the transect and then applying a taught piece of cord along the transect to help define a straight measuring line (Dickinson *et al.*, 1992). If a quadrat is being used then the four corners should be marked and the measuring coordinates within it marked with smaller stakes. The observer is required to accurately identify the species that come into contact with the measuring rod and their height so will

require botanical knowledge of tussock shrubland species. Equipment required for conducting this monitoring is not expensive or difficult to engineer, but is not readily available for purchase (see table 7).

It is suggested that the height-frequency data be incorporated with other objective data (Dickinson *et al.*, 1992; Wiser & Rose, 1997), such as photo points. It is possible that this method can be used to gain indirect biomass estimates from the data (Wiser & Rose, 1997).

Table 7: Special equipment required for monitoring using height - frequency methods

Equipment Required	Use
Height-frequency recording device	For taking the height-frequency measurements, the volume and shape of the device will need to be determined and then the device custom made.
Metal standards	To permanently mark the measuring sites
Wire or cord	For marking the measuring sites or transect

2.3.2.6 Tagged Plants

Monitoring vegetation using tagged plants consists of marking each plant with a tag so that it can be identified and studied individually. By tagging plants and identifying, measuring and mapping them, it is possible to measure species distribution and density (Sukumar *et al.*, 1992). This method is the basic tool for studying plant demography across most vegetation types in New Zealand, from grasslands (Payton & Mark, 1979; Sewell, 1952) to mistletoe (Kelly *et al.*, 2000; Sessions & Kelly, 2001; Sweetapple *et al.*, 2002). Tagged plant monitoring is not one of the most commonly used method for monitoring vegetation change in tussock grasslands and shrublands, due to the often dense vegetation composition in these ecosystems and the difficulty in identifying individual plants. The primary drawback of this method is the intensity in labour hours required to use it effectively. Tagging plants to monitor vegetation change is much easier when individual plants can be clearly distinguished and easily measured. (Rose & Platt, 1990) states that distinguishing individual tussock plants usually requires the tussock canopy cover to be less than 50%.

This method would be beneficial to use when monitoring threatened or rare species (Singers, 1998) or species of specific importance to the objectives of monitoring. When monitoring objectives focus on a single species tagging plants is an efficient method for repeating monitoring in the future. Tagging plants that are particularly palatable to grazing or browsing

would provide information on browsing or grazing intensity and its effect on these plants (Gruener & Norton, 2006). It is more efficient to use this method when the plants being monitored are larger plants or lower frequency plants. It is not possible to measure vegetation composition using this method as it focuses on individual plant demography and not distribution or abundance. For this reason tagged plants are often used in conjunction with other monitoring methods or when the objectives of the monitoring require individual plants to be monitored closely.

This method is effective for measuring a species or range of selected species responses to different management practices (Klöppel *et al.*, 2003). It is also effective for monitoring selected plants in different natural environments (Walker, 2002). Monitoring using tagged plants does not require much botanical or ecological knowledge as plants are specifically marked and do not need to be identified. Equipment required can be found in (table 8).

Table 8: Special equipment required for tagged plant monitoring

Equipment required	Use
Markers (tags)	For identifying each plant

2.3.2.7 Biomass

Biomass is the total dry weight measurement of living plant material, which can be measured as above ground biomass and/or below ground biomass. Above ground biomass is where all the plant material is harvested from above the soil surface and returned to a laboratory where it is sorted into living and dead material. The living material is then oven dried for a day or two and then immediately weighed, ensuring that no moisture from the air is taken back on by the plant. Below ground biomass is obtained by taking soil samples from beneath the plant and sorting the living material from other material and repeating the drying and weighing processes. The problem with below ground biomass measurements is the difficulty in sorting the living material that may not be attached to the rest of the plant (roots etc), between different plant species. These methods can be laborious and are very destructive compared with other vegetation monitoring methods used in conservation monitoring. Because of its destructiveness; it is also not repeatable (Goldsmith, 1991). Such a destructive method is also not suitable for use in reserves and areas where biodiversity is being protected and especially for monitoring sensitive or vulnerable plants. If monitoring the functioning properties of the vegetation it is essential to use a method like this (Clarke, 1986).

A more efficient but less accurate method for obtaining biomass is from taking measures of plant size from its basal area, area at breast height and/or its foliage area (Clarke, 1986). These measures can provide coarse estimates of a plant biomass, but can become more precise if calibrated against previous measurements. Once initial measurements have been taken it is also possible to utilise less destructive methods such as canopy interception and plant spectrereflectance (Clarke, 1986). Biomass measurements can also be calculated from data that is collected using other vegetation monitoring methods. One such method that allows the observer to estimate above ground biomass is the point-intercept method (Dickinson *et al.*, 1992; Grove *et al.*, 2002; McIntosh *et al.*, 1983), where contacts on the measuring device are often proportional to the total weight of the vegetation present (Clarke, 1986). Biomass can be derived from remote sensing techniques, which is useful when calculating biomass for large areas (White *et al.*, 2000), and from plant volume (height and width) (Sage *et al.*, 2009; Widyatmoko & Norton, 1997), which is useful for localised measurements. While it is possible to calculate the percentage biomass for each species within a defined area, it is not possible to calculate the vegetation density, composition or frequency using a biomass method (Clarke, 1986).

Biomass measurements are often taken to determine soil quality, composition and biodiversity (Ghani *et al.*, 2007; Haynes, 2000; McIntosh *et al.*, 1983; Saggar *et al.*, 2001; Yeates & Saggar, 1998), when measuring carbon stocks (Coomes *et al.*, 2002; Davis *et al.*, 2003; Hall *et al.*, 2001; Tate *et al.*, 2000; Tate *et al.*, 2001) and variations are regularly used in marine studies (Clark, 2001; Ogilvie *et al.*, 2000; Willis *et al.*, 2003). Biomass is usually utilised as a measure of plant productivity and functionality and because of this it will not be as useful as a more simple and efficient vegetation composition method.

The equipment and knowledge required for this method will vary greatly depending on what techniques are used (see table 9). The equipment required will be much less for techniques where estimation is used and they will also take less time. When estimating samples do not need to be taken back to the lab for analysis and therefore labour and laboratory demands are avoided. If the more accurate method is used where samples are taken from the field and analysed in a laboratory then the resources and equipment required is greater. When samples are taken for analysis the laboratory analyst must be able to identify different species tissues so that they can be sorted accurately, which requires a large degree of botanical knowledge.

Table 9: Special equipment required for biomass monitoring

Equipment needed	Use
With Samples Taken	
Laboratory space	To analyse samples
Oven	For drying the samples of moisture so they can be weighed without water content
Estimating samples	
Tape measure	For comparing scale and size of plants

2.3.2.8 Remote Sensing for vegetation monitoring

Remote sensing can come in the form of satellite imagery (generally for large scale systems) or aerial photography or radar (much smaller spatial scale for localised areas) (Spellerberg, 1991). Remote sensing techniques are invaluable for monitoring global (Defries *et al.*, 2000), national (Walker *et al.*, 2006) and regional (Dymond & Shepherd, 2004) vegetation change and local scale monitoring is becoming increasingly feasible with technological advances. The key limitations of using remotely sensed data is resolution (spatial, spectral and temporal). Spatial resolution is a measure of how accurate the data is at depicting an area of vegetation on the ground i.e. the amount of groundcover represented by each pixel (see figure 10). The spatial range will vary from high resolution (0.6 - 4m) through to low resolution (30 - 1000m) (Satellite Imagery Coporation, 2009). Spectral resolution is the number of spectral bands or bandwidth that a sensor is capable of detecting (see figure 11). The more bands that are available mean that the image can be analysed more accurately. The position of the bands within the electromagnetic spectrum is also important for the objectives of the monitoring. High spectral resolution is 220 bands through to low spectral resolution with 3 bands (Satellite Imagery Coporation, 2009). Temporal resolution is a measure of how frequently the data is obtained for a specific area. This depends on the orbit of the satellite and can range from less than a day (Quickbird and IKONOS) to more than 16 days (Landsat) (Terralink, 2008).

Due to the current technical restraints of remote sensing, there must be a trade off between the resolutions. This means that if high spatial resolution is used then low spectral resolution must be used also (Satellite Imagery Coporation, 2009). Because of this the objectives of the monitoring must determine which is more important, or whether medium resolution for both is acceptable. If organisations like QEII or LEAF were to decide to obtain data it would likely be

from the Modis Satellite which has spatial resolution of 250m (2 x bands) or 500m (3 x bands) or LandSat satellites.

National databases are available in the form of the Land Cover Databases (LCDB) for assessment of vegetation cover and change (Walker *et al.*, 2006), usually in conjunction with Land Environments New Zealand (LENZ). Even on a national scale where precision is not required to the same extent as monitoring a several hectare block, the accuracy from analysing these databases for small spatial scales has come into question (Brockerhoff *et al.*, 2008). These national databases are freely available from the Ministry for the Environment, but if they are not sufficient for the purposes of your monitoring then data can only be obtained from third party sources. It would be up to the organisation to obtain the relevant data at their own cost when necessary. Data can range in cost from free to air for low resolution data to up to \$100 per km² for high resolution data, without any processing (Bellis, 2006). Although packaged data is available that has been classified for the customer, it would have to be suited to the specific needs of the client, which would be different for each property. Raw data comes in the form of an image that contains ‘bands’ or layers that detect different reflectance values from the monitored surface. This data can then be classified using known values to give a visual output of the current vegetation composition. This data can then be compared with previous or more recent data to calculate the change in vegetation over time.

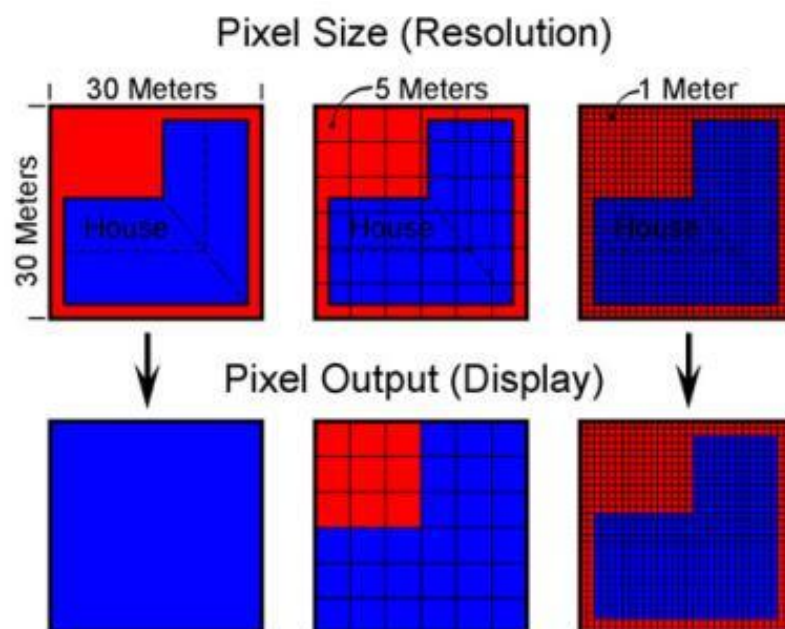


Figure 10: Shows how spatial resolution (pixel size) of an image is related to what is being represented from the real world.

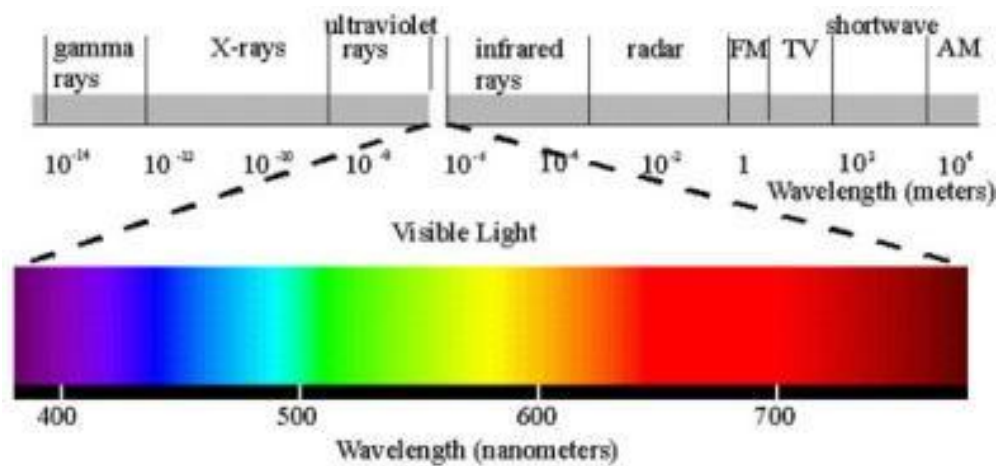


Figure 11: The electro-magnetic spectrum shows the different wavelengths of light. Different sensors pick up different wavelengths of energy. Each band is shown on the image.

Extensive field work is still required to assess the accuracy of the data (Lee *et al.*, 2005). If extensive field work is not conducted then errors can reduce the accuracy of the analysis. The lack of sufficient field work on the LCDB data is seen by (Brockerhoff *et al.*, 2008) to be the reason for the errors they have identified in the (Walker *et al.*, 2006) study. While remote sensing is a proven method for detecting vegetation change, questions have been raised about its ability to monitor certain aspects of biodiversity and ecosystem attributes. Large components of biodiversity are poorly covered by such approaches, if at all (Lee *et al.*, 2005; Turner *et al.*, 2003). Because a number of the covenants are small in size (many being $< 5\text{ha}$), it would be difficult to accurately measure subtle change in these ecosystems unless high resolutions are obtained spectrally and spatially. There are a large number of threatened groundcover species (mosses, ferns etc) in the study areas that would still require more traditional methods to monitor. Regional and local authorities are placing more emphasis on vegetation survey and monitoring, especially for pest plants using remote sensing (Lee *et al.*, 2005). Special equipment required can be found in (table 10)

Table 10: Special equipment required for monitoring using remote sensing of vegetation

Equipment needed	Use	Cost
Computer	For accessing, storing and analysing the data. Specifications will vary with the size of data sets and the type of analysis that will be conducted	\$1500-\$2500 generally. The computer would need to meet the minimum requirements of the software being used
Remotely sensed data	This will be the raw data for analysis	Free - \$100 per km ²
RS software for classification	Specialist software is required to classify and analyse the data. GIS software may be required to combine other bio geographic data and to produce graphic outputs.	Will vary but can be expensive
For Field Work:		
GPS system	For locating and recording sites for accuracy assessment	Will vary depending on quality but can pick one up for around \$300
Field note book	Recording results from field inspection	
Camera	It may be beneficial to photograph each site for future reference	

2.4 Discussion

Feedback from stake holders including land managers and the scientific community on monitoring methods is a crucial input into developing best practice techniques for both management and monitoring programs for biodiversity protection. Research has been conducted using various vegetation monitoring methods on South Island tussock grasslands by local authorities, scientific institutions and land management agencies since the 1930's. The fate of these studies varies substantially from being published in referenced journals to not being published at all (Allen, 1993a). One of the major problems is that when these studies go unreported (whether they were successful or unsuccessful) the feedback loop between the scientific community, land managers and the public is broken, which means important knowledge is lost. Although where ongoing practical land management is concerned ongoing feedback from any source is not necessary.

Allen (1993) found that from a total of 56 studies that monitored vegetation changes in South Island tussock grasslands, 43% remained unreported, which is a big hole in knowledge that is created by the lack reporting whether they are successful or not. Of the 56 studies, 45% monitored vegetation change in response to management techniques such as grazing intensity, exclosure of animals and control of feral species (Allen, 1993a). Some of the most common reasons for monitoring programs failing are due to a high or conflicting demand on resources, limited funding or staff turnover (Norbury & Norbury, 1996). Allen (1993) states that uncertainty about the appropriate monitoring methods and objectives are seen to be a major contributing factor to the lack of presentation of results from many studies. From a scientific perspective the reporting of studies whether it failed or not would be in some way beneficial. If the reasons for why it was or was not successful can be identified then it can benefit future monitoring programs. This would provide valuable feedback on which methods are more suited for monitoring specific objectives.

All ecological monitoring methods require a degree of botanical and ecological knowledge to identify the species present. Knowledge and experience in monitoring grasslands is seen as being beneficial due to the densities at which they can grow and the sod-forming of some species (Clarke, 1986), which shouldn't be an issue for QEII field representatives, but could be a problem when land managers conduct monitoring. Permanent plots like quadrats are effective and robust methods for monitoring vegetation and can quantitatively assess the impact of grazing animals (Clarke, 1986; Daniel & Rasmussen, 1985), which is an important attribute for the sites in this research. Although setting up and maintaining permanent plots is expensive (Allen, 1993a) and in some cases the resources available may not allow for certain methods to be implemented effectively. It is also recommended where possible to utilise a range of methods in one study (Rogers, 1991) to gain information required by the objectives of

the monitoring. For monitoring on private land methods need to be cost effective and have low resource demands, which mean that some methods are far more suited than others.

As mentioned earlier in this chapter, each monitoring site should be located with one main identifying stake that should be clearly visible from a distance and should include relevant site information for accurate replication of monitoring (Allen, 1993b). If the observer has GPS then this will assist in locating and recording the sites more quickly. This will also allow the data to be transferred into a Geographic Information System (GIS), which is a powerful and cost effective tool with a skilled operator. If data can be stored digitally then it allows for easy transfer, storage and replication, which could be beneficial if QEII or LEAF were to decide to compile monitoring information into larger scale databases.

Each of the methods has been compared according to their objectivity, intensity, scale, resource demands, repeatability, technical expertise and information content for vegetation response to grazing (see table 11). While every effort has been made to make this table as accurate as possible it is difficult to categorise each method so simply. This table will serve as overall comparison between methods for the purposes of monitoring vegetation change in response to management decisions on private land. It must be noted that resources are a primary consideration, which alters the resource demand of each method. Intensity is also affected by limited resources, so for another study that has 3-4 observers then a method may not be seen as intensive, but for this study that has only one observer then a method may be seen as highly intensive. Scale will refer to the scale at which each method is more suited and not what scale each method is capable of. Transects have been included, although it should be noted that another method will have to be used in conjunction to monitor the vegetation. For the purposes of this table it will be assumed that vegetation is visually ranked at samples along the transect.

Table 11: Comparison of the monitoring methods reviewed in this chapter

Method	Objective/ subjective	Intensity	Scale	Resource demands	Repeatability	Technical expertise	Info content on grazing
Formal Visual	Subjective	Easy	Landscape	Low	Easy	High	Medium – high
Photopoints	Either	Easy – moderate	Landscape & site	Moderate – low	Easy	Medium	Low - medium
HF's	Objective	Difficult	Site	High	Moderate	High	High
Transects	Objective	Moderate	Site	High	Moderate	High	Medium
Quadrats	Objective	Moderate	Site	High	Moderate	Medium	High
Tagged plants	Objective	Difficult	Site	High	Moderate	low	Medium
Biomass	Objective	Difficult	Site	Moderate – high	Difficult	High	High
Needle point	Objective	Moderate	Site	High	Moderate	Medium	High
Remote Sensing	Depends on the amount of field work conducted	Moderate – easy	landscape	Depends on data acquisition	Easy	Very high	Low – medium

3 Chapter Three – Case Studies

Case study properties with legal covenants for protecting biodiversity

In order to determine what is occurring in the field in terms of monitoring, case studies will be used. By reviewing these sites in conjunction with the methods reviewed in chapter two it will be possible to establish how suitable the methods being used are. Case studies will be comprised of sites from throughout the Canterbury region and will include high country and lowland sites. Canterbury has been highlighted as a significant contributor to national biodiversity (Heads, 1997) and it contains sites that are both above and below 500m asl, which is a figure commonly used to broadly distinguish between environments in New Zealand (Norton, 2001; MfE, 2007). The properties that were selected have QEII open space covenants and are comprised of tussock grasslands / shrublands that have significant native biodiversity values present. These properties have been selected in conjunction with the North Canterbury and South Island High Country field representatives from QEII, Miles Giller and Brian Molloy, as well as David Norton (see figure 12). Although there is one case study that has been selected that does not have biodiversity values present, but it does provide the potential for comparison between grazed and ungrazed ecosystems on the same site (Banks Peninsula).

Each of the selected properties covenants contain clauses within the terms of the covenant to allow for ongoing economic use (grazing). Grazing within these covenants is controlled and the seasonality, duration and intensity are managed according to ideal management and monitoring feedback. Grazed covenants have been used because it is unclear whether current monitoring is sufficient to ensure biodiversity values on land under ongoing economic use are being sustained. They also require monitoring that has good information content on vegetation change in response to grazing to ensure that grazing levels are beneficial to the covenant.

Case studies have been used as a current example of what is currently occurring in the field in terms of monitoring vegetation change in privately protected QEII covenants. The primary focus of this research is on covenants due to their significance and popularity for biodiversity protection on private land. Monitoring on these properties will be assessed to determine whether adequate information is being obtained from the monitoring methods used. This is especially important for grazed covenants as management regimes rely on the outcomes of the monitoring acutely. Appropriate grazing regimes are determined by changes detected (can be positive or negative) by the monitoring. It is important that the right information is being collected from the monitoring program, so that the most appropriate management decisions are implemented, which in turn will benefit the biodiversity within the covenant.

Each property will be briefly examined to determine what biodiversity values are present. This will include information on species that may be of specific interest either regionally or nationally, as it is likely that these species will need to be monitored more specifically. Current and future land use will be examined to determine how the covenant is being grazed and how it is likely to be grazed in the future. The monitoring methods that are used will be provided to establish what methods are used in the field, as well as frequency of repeat monitoring. Due to the sensitivity of some covenant information the purpose of this chapter is primarily to ascertain which methods are used and the frequency that they are repeated. Due to the relatively new nature of open space covenants a lot of properties monitoring programs have not yet been finalised.



Figure 12: Covenant locations throughout the Canterbury region

Species that have been identified as threats to the covenant by the field representative are provided to gain an idea of the key threats to native biodiversity values. It will then be possible to determine whether current monitoring is providing enough detailed information about vegetation change in these covenants. If the monitoring is not sufficient, advice on what action should be taken to improve the monitoring and management of privately protected biodiversity will be provided. The general monitoring frameworks that have been set in place by QEII will be reviewed as they provide the overall structure to monitoring nationally (chapter 4). Having effective frameworks in place is critical for creating a consistent and appropriate national or in LEAFs case a global monitoring system.

All information in this chapter has been obtained from QEII covenant documents (see appendix 1, 2 & 3 for templates), the QEII field representatives (Miles Giller or Brian Molloy), land managers and field visits, unless otherwise referenced. The information available between the field representatives is different due to their individual preferences for storing and recording information on their covenants. Where possible information will be uniform across all case studies, but this may not be possible in every instance due to available information.

QEII use a set framework for assessing what values are present in the property including geophysical information (appendix 1) and biodiversity information (see appendix 2). For each property a baseline survey establishing what species is conducted and recorded, which is developed in part from information gathered in (appendix 1 & 2). A QEII monitoring report template can be found in (appendix 3). This report forms the basic structure for all QEII monitoring.

3.1 Canterbury Plains sites

These sites are located on the Canterbury Plains, which are low lying flat lands on ancient alluvial flood plains. These lands have very high productive potential and because of this the vast majority of primary ecosystems have been disturbed and only secondary ecosystems or primary remnants remain. The ecosystems that remain in these highly productive lowland areas are generally highly resilient to grazing and other disturbances as they have persisted to survive to this day. Restoration of these ecosystems to their previous states is very difficult if not impossible because they have crossed through ecological thresholds (Hobbs & Norton, 2004). The key objectives for the majority of covenants in this area involve preserving what is there now and not trying to restore what was previously there.

3.1.1 Eyrewell Station

Eyrewell Station is located in the Eyrewell district of the Canterbury Plains, on an alluvial terrace on the northern bank of the Waimakariri River, 27km northwest of Christchurch city. The site has an altitude range of 125 – 130m asl and slopes gently to the east. Average rainfall in the region is 760mm per annum. The covenant consists of two blocks (c. 2.1ha combined) that are similarly comprised of predominantly modified primary Kanuka scrub and shrubland (see figure 13). The New Zealand map grid references for the two blocks are M35 563 569 and M35 567 576.



Figure 13: Aerial photograph of the Eyrewell Station covenants with blocks A and B shown

Early vegetation was likely to have been burnt by early Maori or European settlers and has likely been grazed ever since. The current composition of the kanuka shrubland has been compared to that of the original kanuka shrublands before post - Maori fires, although there is still some debate about the precise state of those shrublands. The department of Conservation (Doc) only have 4.9ha of similar kanuka shrublands protected on the Canterbury Plains. The only other similar ecosystem in the area is the Eyrewell scientific reserve which is 14km away.

There are a few larger kanuka plants present in the covenant which has led representatives to believe that other plants have not yet reached full size and are still developing. The kanuka plants seem to have lost vigour due to infestation from scale insects but the representatives do not see this as threatening long term.

This covenant contains a grazing clause to allow stock grazing to be integrated into the management plan. For this covenant it was noted that grazing should not be by cattle or heavy mob-stocking by sheep due to the Kanuka species vulnerability to heavy grazing (see figure 15). It is stated in the conditions of the covenant that levels of grazing should be adjusted seasonally and in response to monitoring outcomes. Sheep and cattle have had controlled access to the covenant for grazing for several decades and the ecosystem has still survived. Grazing will continue into the future unless monitoring suggests that it has become detrimental to the values within the covenant.

The current regime to continue and monitor the effect that grazing is having on the ecosystem and the individual species within it. Grazing intensity, seasonality and type can all be adjusted accordingly, when the monitoring shows that the current regime is not sustaining the biodiversity values present. For a site like this that has been grazed for the past several decades grazing is unlikely to cause any acute decline in any of the present species. These species have remained under this type of pressure and have now have built up some resilience to this type of disturbance. Despite intense and prolonged grazing this area is still seen to be of similar to condition to pre-human burning. Management of invasive species is primary objective due to the proximity of a plantation forest and also other woody species like gorse. The key here is that the ecosystem dynamics are unlikely to change drastically for the better or worse while it is managed like this.

Several photo points have been set up in the covenant (8 in total) representing specific condition as well as more general condition, especially for areas with abundant mosses (see figure 16). Each photo point is revisited and measured biennially. The representative also noted that a site like this may require more frequent monitoring than the current biennial period. There is a small area of kanuka plants that lie outside the covenant that are more frequently grazed at a higher intensity. Although that area is unlikely to provide much contribution to the overall biodiversity of the area, it provides an excellent example of what happens to areas like this when grazing is less controlled. This area is monitored using a photopoint to provide a contrast between the two sites. All of the wildlife that are sighted, heard, tracked or captured while the representative is in the covenant are recorded.

3.1.1.1 Values present

The Kanuka scrub and shrublands are the key significant value present in this covenant, but Nick Head (DoC) has stated that the groundcover is also of significant importance for this site. The groundcover consists of abundant and diverse mosses (*Hypnum cupressiforme*, *Racomitrium pruinosum* *Leptinella serrulata* and *Dichondra repens*) and various grasses (see

figure 14). In this covenant palatable species appear to be absent and there is no established understory present. Threatened species in this covenant include *Kunzea aff. ericoides* 'Species C', *Leptinella serrulata* and Miromiro (South Island Tomtit).



Figure 14: *Leptinella serrulata* (a threatened species listed as Gradual Decline), taken in Eyrewell Station covenant block A.



Figure 15: Difference to Kanuka species with mob stocking (left of fence line) and with controlled grazing inside the covenant (right of fence line)

Table 12, species present at Eyrwell Station and their location in the ecosystem

Location	Species Present
Canopy	Kanuka (<i>Kunzea aff. ericoides</i> 'Species C')
Understory	<i>Discaria toumatou</i> , <i>Carmichaelia australis</i>
Ground Cover	<i>Hypnum cupressiforme</i> , <i>Racomitrium pruinosum</i> , <i>Leucopogon fraseri</i> , <i>Leptinella squalid</i> , <i>L. Serrulata</i> , <i>Microlaena stipoides</i> , <i>Carex breviculmis</i> , <i>Dichondra repens</i> , <i>Muehlenbeckia axillaris</i>
Threats to values present	Gorse, <i>Hieracium pilosella</i> , <i>Hieracium lepidulum</i> , Exotic grasses, Rabbit, Hare, Possum, Wild cat,



Figure 16: Photo point in within Kanuka stand. Yellow tags on one of the plants indicates the centre of the photograph



Figure 17: Gorse plants shown (centre photo) within the Eyrewell covenant

It has been noted that woody weeds (particularly gorse) pose a significant threat to the values present in this covenant (see figure 17). Exotic grasses are beginning to become abundant and if they are allowed to become rank then it is likely that they would out-compete the smaller native species. If this occurred then it could prevent future recruitment of Kanuka.

3.1.2 Mount Alexander

Mt Alexander is a 16ha secondary montane dryland scrub and shrubland covenant located north-east of Christchurch city at grid reference N33 942 151 (see figure 18). The site overlooks the Hurunui River in the Culverdon Basin and is predominantly comprised of secondary montane pohuehue, matagouri and *Caprosma* species. The site has a range of altitude from 260m – 420m a.s.l and has an average annual rainfall of 550mm. Site aspect is mainly north to west facing with arid exposed hillsides, which is exacerbated by wind erosion and rabbit burrowing. Geology consists of greywacke with shallow loess cover in some areas. Soil at the site is a well developed yellow-grey earth.

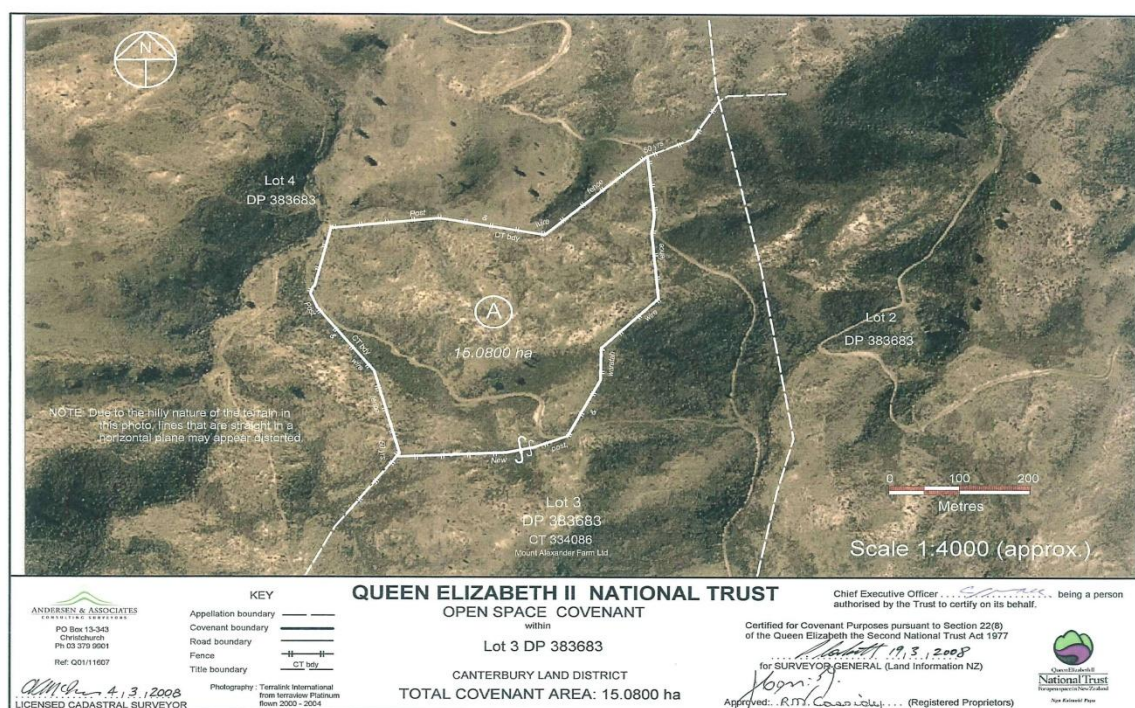


Figure 18: Aerial photograph of Mt Alexander covenant

Connectivity within the area is high as the surrounding land type and cover is fairly similar. This reduces the covenants rarity and distinctiveness as it is typical of the surrounding dryland east-coast hill-country. Although the covenant is not distinctive from its surrounding farmland, it is very distinct from most other covenants and reserves. It also has significant variations between the northern slopes, western slopes and ridges, which has divided the covenant into 3 Ecological Management Units (EMUs). Formal protection of this type of ecosystem, although secondary, is greatly under represented.

The covenant is not divided by ecosystem, but instead the boundaries are linked to existing fences on the property to reduce costs. These ecosystems have survived burning, grazing and intense browsing from rabbits for decades, but succession may gradually lead to a denser cover and a higher proportion of the woody native scrub species.

This covenant contains a grazing clause to allow stock grazing to be integrated into the management plan. Grazing is only permitted on open grassland areas of the covenant due to the density of woody species and the only stock used for grazing purposes are sheep. As part of this clause the grazing must be monitored by QEII representatives and management adjusted accordingly if there are any adverse impacts on the present biodiversity.

Current monitoring consists of photo points that have been set up to monitor canopy, under storey and ground cover. The representative conducts a walkthrough of the covenant to monitor vegetation condition and to assess the need for pest management. Covenant fencing

condition is checked and recorded and any necessary protection of significantly threatened species made. This may involve removing rank grasses directly surrounding a plant or constructing an enclosure to remove grazing pressures. An example of necessary protection for significant species was on my visit to the property when an enclosure was erected around a threatened *Muehlenbeckia astonii* plant that had obvious grazing damage (see figure 19).

All of the wildlife that are sighted, heard, tracked or captured while the representative is in the covenant are recorded. Threats to biodiversity within the covenant are monitored visually and with photographs to enable appropriate management, whether that is conducted by the representative or the land manager will depend on each situation. Minor pest management measures are conducted while the representative is on site, whether it is managing threats noted in previous visits or threats noticed on this visit. Major problems like gorse infestations are reported to the land manager to complete.

Although this site has been quite highly modified and is secondary, it still has potential for succession into denser species cover and a higher proportion of woody species. Management needs to reflect this potential for succession by directing the area towards that. To achieve this monitoring needs to be accurate and effective to provide good information on the management regimes.

3.1.2.1 Values present

The emergent species consists of scattered small trees and large scrubs. There is no distinct canopy cover in this covenant because the climatic conditions and geography of the area create a dry ‘scrubby’ environment. For the purposes of this case study these species will be listed as scrub as they do not resemble a traditional canopy. This zone of vegetation is comprised of virtually impenetrable short woody cover that is in scrub portions and broken by patches of short grasses in shrubland portions. The understory is very limited by browsing, in particular from rabbits. Drought conditions have also limited the growth in the understory. Groundcover is dominated by a small range of species with a low-palatability (see table 13).

There are also several threatened species present within this covenant including the nationally threatened *Muehlenbeckia astonii*. The sparse *Muehlenbeckia ephedroides* and the data deficient *Vittadinia australis*, *Clematis quadribacteolata*, *Clematis marata* and *Clematis afoliata* are also significant values found on the property.

Table 13 Species present at Eyrewell Station and their location within the ecosystem

Location	Species Present
Emergent	<i>Sophora prostrate</i> , <i>Coprosma propinqua</i> , <i>Coprosma virescens</i> , <i>Discaria toumatou</i> , <i>Cordyline australis</i> , <i>Kunzea aff. Ericoides</i> , <i>Carmichaelia australis</i>
Canopy	<i>Coprosma propinqua</i> , <i>Discaria toumatou</i> , <i>Muehlenbeckia complexa</i> , <i>Poa cita</i> , <i>Festuca novae-zelandiae</i> , <i>Carmichaelia australis</i> , <i>Pteridium esculentum</i>
Understory	<i>Pteridium esculentum</i> , <i>Polystichum richardii</i>
Ground Cover	<i>Poa cita</i> , <i>Asplenium flabellifolium</i> , <i>Oxalis exilis</i> , <i>Rytidosperma sp.</i> , <i>Polystichum richardii</i>
Threats to values present	Old man's beard, Gorse, Broom, Nassella, <i>Pinus muricata</i> , <i>Pinus nigra</i> , <i>Urtica urens</i> , <i>Conium maculatum</i> , Winged thistle, Rabbit, Burning, intensification (especially deer or goats), conversion to forestry and neglect (and subsequent woody weed encroachment).

A key threat to this site is neglect and invasion of woody species, which go hand in hand with each other. The more a site is neglected, the more invasive species take hold. Balmoral Forest is only a few km's from the site, which provides a ready supply of seeds of various *Pinus* species with the right wind conditions (see figure 20). On a site like this management clearly needs to place a strong emphasis on pest management. During a site visit in 2008 we discovered several large wilding pines of a range of different pest species, many of which were controlled while there. Exotic broom, gorse, thistle and OMB were also removed and treated while on this site visit. All of these plants were quite developed and had they been left any longer could have become a much bigger problem for the covenant.



Figure 19: QEII field representative taking a monitoring photopoint, with a *Muehlenbeckia astonii* plant in the background within an enclosure.



Figure 20: Pinus species being controlled while on site at Mt Alexander

Ideally the land owner / manager should be taking care of pest management in the covenant the same way they do for the rest of the property. Unfortunately for a small number of properties this is not the case and pest management is left to the QEII field representatives on their scheduled monitoring visits. As anyone who has conducted pest management rurally would know, it takes a lot of time, effort and resources. When field representatives have to strain already strained resources further to conduct pest management time for other vegetation monitoring is very restricted.

3.1.3 Anderson (Collessie)

The Collessie covenant is comprised of two lowland secondary kowhai forest and grey scrub shrubland blocks (see figure 21). These two blocks are contiguous, although differentiated by the grazing management regimes. Block A, which is the northern most block (N33 105 177) is 10.8ha and block B (N33 106 440) is 7.3ha. The site has an altitude range of 300m – 454m and annual rainfall is 800 - 900mm.



Figure 21: Aerial photo of Andersons covenant showing blocks A and B

Currently the two blocks in this covenant are managed differently. Block A has had all grazing removed unless necessary for management purposes and Block B is unfenced and still grazed. As both blocks have similar ecosystems and climatic conditions, with good monitoring this situation can provide an excellent comparison between blocks. The current grazing in block B is restricted by the composition of the vegetation present. Because it is dense shrubland the sheep do not tend to push their way into the vegetation too deeply, where as cattle tend to push

through the shrub a bit further. Currently block B has the following grazing regime, where it is mob stocked for 8 months (1 in every 4 weeks). Set stocked from cattle depending on conditions and set stocked with ewes September through December.

Because this covenant is approved but not yet registered, Miles Giller (QEII) will be setting up photo points when he returns to the covenant next. He took some sample photos while inspecting the covenant fencing on the last visit. So at the moment there is no monitoring program in place. The land owner and Miles talked about putting together a document that outlined some direction and goals for the covenant, which will greatly improve the direction and structure of the monitoring. This covenant provides a prime opportunity to monitor near identical ecosystems with grazing and a control. One of the key objectives for this covenant as identified by the field representative and the land owner are the dryland associations and especially those associations dominated by the two *Sophora* (*microphylla* and *prostrata*) species (see figure 22).

The land owner/manager for this property was very interested in how the covenant progresses and is managed. He is keen to develop some management objectives for the covenant as a whole and for the monitoring within the covenant in conjunction with the field representative. While he was interested in the ongoing monitoring of the covenant he was not interested in developing an extravagant and unnecessary monitoring program. A simple and less intensive method was seen as being appropriate to ensure that the objectives of the covenant were being met and managed effectively.

This site differs enormously from the Mt Alexander site simply with regards to the land owner / managers attitude towards management of their covenant. Here the land manager is very interested in preserving this land and seeing some succession in the future and has translated this into an effective and successful pest management program. This is not to say that other land owner /managers are not interested in their covenants if they do now effectively manage pests. There is however a distinct difference between how this owner / manager has converted this interest into effective management of the covenant. Pest management is conducted thoroughly and at regular intervals to the point that there are very few threats to this site. The current management will continue, unless monitoring shows that it is detrimental to the biodiversity or showing no improvement. Browsing effects can be seen on a *Sophora prostrata* species in (figure 23). This site has a lot of potential to improve monitoring and management of grazed covenants, because the representative can focus more on biodiversity monitoring and there are two blocks managed separately.

3.1.3.1 Values present

Canopy has *Sophora prostrata* and grey scrub species throughout, bracken in basins and silver tussock on ridges and fences. Emergent species are comprised of strong regeneration of kowhai (prostrate and tree) throughout. There are two adult kaikomako present as well as grey scrub species emergent in scrub and shrubland areas. The understory has a good range of browse-resistant grey scrub species present. Mahoe and *Carmichaelia australis* may benefit in Block A after exclosure from grazing. Groundcover is somewhat constrained by grazing. There is a strong population of *Asplenium flabellifolium* throughout and moss species and lichens are locally abundant (see table 14).

Table 14, Species present in the Collesie covenant and their location within the ecosystem

Location	Species Present
Emergent	<i>Sophora microphylla</i> , <i>Sophora prostrata</i> , <i>Melicytus ramiflorus</i> , <i>Coprosma crassifolia</i> , <i>Coprosma propinqua</i> , <i>Coprosma virescens</i> , <i>Discaria toumatou</i> , <i>Carmichaelia australis</i> , <i>Melicytus</i> 'alpinus group' (3 species)
Canopy	<i>Sophora microphylla</i> , <i>Sophora prostrata</i> , <i>Coprosma crassifolia</i> , <i>Coprosma propinqua</i> , <i>Discaria toumatou</i> , <i>Carmichaelia australis</i> , <i>Melicytus</i> 'alpinus group' (3 species), <i>Clematis afoliata</i> , <i>Muehlenbeckia complexa</i> , <i>Fuchsia perscandens</i> , <i>Poa cita</i> , <i>Pteridium esculentum</i> ,
Understory	<i>Coprosma crassifolia</i> , <i>Coprosma propinqua</i> , <i>Coprosma virescens</i> , <i>Melicytus</i> 'alpinus group' (3 species)
Ground Cover	<i>Asplenium flabellifolium</i> , <i>Asplenium appendiculatum</i> , <i>Polystichum richardii</i>
Fauna	Piwakawaka, riroriro, tahou, korimako, kahu
Threats to present values	Nassella, Exotic broom, possum

Indicator species *Sophora microphylla* and *Sophora prostrata* (Kowhai species) indicate likely succession towards kowhai forest and scrub. *Poa cita* to monitor tussockland without grazing in Block A and with grazing in Block B. Mahoe, *Carmichaelia australis* and *Asplenium appendiculatum* to monitor effects of destocking in Block A and effects of ongoing grazing in Block B.

Coprosma wallii is in gradual decline and is very uncommon in North Canterbury lowlands. This population is important for where it is, as much as for the rarity of the species itself. *Melicytus* 'Blondin' is range restricted and has a very strong population of this un-named species. *Melicytus* species variety includes three small-leaved *Melicytus* species growing

together (*M. alpinus* SS, *M. 'Blondin'* and *M. 'Dark'*). *Aciphylla subflabellata* is sparse and there is a small population in eastern tussock land area of the covenant. *Vittadinia australis* is data deficient and has a small population on rock outcrops. *Coprosma virescens* is uncommon in the Ecological District (ED) and is scattered throughout on rock outcrops. *Sohora prostrata* and *S. Microphylla* are in an unusual example of these two kowhai species growing abundantly in close juxtaposition (plus at least one hybrid plant).

This covenant is also seen as an excellent potential habitat for lizards although none have been spotted thus far.



Figure 22: Photopoint (marked by white tag on fencepost) showing a ridgeline, both *Sophora prostrata* and *microphylla* can be seen.



Figure 23: *Sophora prostrata* species. Plants in foreground and ground cover have been quite heavily grazed.

There are few threats to the native biodiversity in this covenant due to the proactive pest management administered by the land manager. Nasella and exotic broom are sparse in the covenant and are currently being managed effectively. Some threats that are present are as follows:

3.1.4 Banks Peninsula

This site is covenanted to protect surrounding rocky outcrop area and has not been directly created to protect any grassland or shrubland systems. Although this case study falls outside the scope of this research as it does not possess the biodiversity values of other properties, It was included because it provided an excellent comparison between grazed and ungrazed grassland areas within the same site. This comparison of grazed vs ungrazed grassland sites is a valuable inclusion to this research and with appropriate monitoring could provide an excellent comparison between two contrasting management regimes.

This site is located on Banks Peninsula on the upper slopes, bluffs and ridge crests of the Port Hills overlooking Lyttelton Harbour. It is 28.16ha of steep rocky land that is clad in secondary podocarp -hardwood vegetation. The more gentle slopes of the property are covered with exotic pastures with native tussock species, ferns and other woody species scattered

throughout. Aspect is generally SE at an altitude range of 160m – 490m asl and average rainfall of 750mm 1,000mm per annum. Connectivity with similar ecosystems is contiguous with similar QEII covenants and reserves in the area.

Currently there are four photopoints set up within the covenant monitoring various aspects of the covenant. Other monitoring includes wildlife spotting and inspecting covenant boundaries (fencing), as well as identifying and managing pests (see figure 25). There is a comparison available between tussock grassland areas because one has enclosure from grazing and the other is grazed.

3.1.4.1 Values present

As mentioned previously the majority of the values present in this covenant are not the focus of this case study (see table 15). The grasslands contain high frequencies of exotic and rank grass species. The key value in the grassland areas is silver tussock, which is protected from rank grasses to a degree by ongoing grazing (see figure 24).

Table 15, Species present in the Banks Peninsula covenant and their protection status

	Species Present
Banks Peninsula	<i>Hebe strictissima</i> (Range Restricted), <i>Raoulia monroi</i> (GD), <i>Vittadinia australis</i> (DD), <i>Coprosma wallii</i> (GD), <i>Heliohebe lavaudiana</i> (Serious Decline), <i>Senecio glaucophyllus</i> ssp <i>basinudus</i> (RR), <i>Aciphylla subflabellata</i> (Sparse), <i>Leucopogon fasciculatus</i> (uncommon in ED, ER), Kereru (GD)
Threats to present values	Cotoneaster, Cherry, BPF, Barberry, Wilding Pines, Gorse, Old Mans Beard (OMB), <i>Hoheria sexstylosa</i> , Broom, Blackberry, Current, Elderberry, Spindleberry, Burdock, Possum, Rat, Fire



Figure 24: Photopoints showing a comparison between rank grasses (left side of fence line) and protected tussocks (right side of fence line). Image A (left) is taken in 2006 and image B (right) is taken in 2008.

This site has a large number of active and potential threats to biodiversity and some of these may be attributed to the sites close proximity to Christchurch city. One site is grazed and the other is protected which provides a good comparison between two separate management regimes in a similar.

3.2 Canterbury High Country Sites

These sites are different to those found on the plains, as they are comprised primarily of tussock grasslands and ‘turf’ species. For this reason these case studies will be compiled in a slightly different manner and contain slightly different information. Brian Molloy is the current QEII high country representative so the majority of information for these case studies is from QEII and Brain. Brian has developed management plans for each of these sites apart from the Rakaia gorge site. These management plans provide direction for the covenant as a whole and provide objectives to focus monitoring more closely on.

3.2.1 Fairlie Basin

This covenant is comprised of two blocks the original 8.62ha block and an additional 6.22ha block. It is located on the alluvial flats of the Orari River headwaters and is accessible by road from Fairlie, 25km to the south. The surrounding area consists of farm land, running 11000 merino sheep, 350 cattle and deer. The site is at an altitude of 600m and the ranges to the north and south have a number of peaks that exceed 1000m. Prevailing winds are northwest and average annual rainfall is 700 - 1000mm. Bedrock consists of greywacke and argillite, volcanic and limestone overlain with minor alluvial and glacial deposits. This site has cool

winters and mild dry summers, which can be droughty. QEII see the property as one of the best managed high country farms in the South Island.

The three main broad objectives of this covenant are:

- A. To protect and maintain open space values of the land.
- B. To protect a representative example of snow or tall tussock grassland ecosystem.
- C. To protect landscape values of the land especially as seen from Lochaber and Mowbray roads.

Key policies for the covenant for vegetation are:

- A. Protection and enhancement of native vegetative cover will be a focus of the management.
- B. Limited grazing by sheep may be permitted in the long term, provided strict monitoring is conducted to ensure there is no damage to the native vegetation.
- C. Pastoral farming activities will be undertaken having regard to the aims of, and the specific management principles established relating to the open space covenant.
- D. No plantation forests will be established and there will be no shelterbelts on or near the covenant area.
- E. The objectives of the open space covenant must be paramount in considering proposals for changes in management practices.

The majority of the monitoring on this property is conducted using visual methods and photo points. The QEII representative for this site noted that the priorities lie in firstly protecting the area, and secondly monitoring fencing condition and pest within the covenant.

The key monitoring policies from the management statement are:

- A. A monitoring process relating to the aims of the open space covenant has been established and is being implemented, with monitoring being undertaken by the trust and the landholder in consultation with other appropriate expertise.
- B. Regular monitoring of the protected vegetation will be carried out and detailed ecological assessment undertaken from time to time by comparison with the adjacent grazed block.
- C. Scientific research will be encouraged to provide further information on the natural and physical resources of the covenant area and the sustainable management of the indigenous flora and its various habitats.

Several photo points have been setup around the property to show the tussocks response to grazing in particular. Field notes are also acquired by the field representative while conducting monitoring using general visual methods.

The covenant will continue to be grazed as a management regime. Grazing should not be detrimental to the ecosystem as it has occurred there for the past 15 years or more. Grazing in this site is seen to be responsible for the current range of biodiversity and health of the ecosystem. Grazing consists of 50 to 100 sheep periodically having access to the area, which is seen to keep the exotic species that are present in the inter tussock zones in control and also to reduce fire hazards. The sheep seem to prefer the exotic species to the native species and they provide the natives with fertiliser. This light grazing by sheep is likely to continue into the future unless it is seen to be becoming detrimental to the tussock species.

3.2.1.1 Values present

The covenant is situated in the northern corner of the Fairlie Ecological District and the original vegetation in this district was tall tussock grassland, with forest remnants in gullies, scrub and wetlands. The primary vegetation surface is narrow-leaved snowgrass (*Chionochloa rigida*) with lesser amounts of blue tussock, fescue tussock, Spaniard, Celmisias, matagouri and a range of other shrublets, herbs and grassland orchids. The snow tussock protected in this site is the only protected area with this vegetation in the ecological district. Exotic species are present. One of the outstanding features of this covenant is the association of tall tussock and a stony alluvial surface. Significant species present in the covenant can be found in (table 16).

There is an area outside the covenant that has similar values but is openly grazed, which with appropriate monitoring has the potential for comparison (see figure 26).



Figure 25: The openly grazed are is in the foreground and the grazing within the fence line in between the two roads is managed.



Figure 26: Roadside shown to the left of the covenant fence line is in close proximity to the covenant.

Table 16, Flora and fauna present and threats to values for Fairlie Basin covenant

	Species
Values Present	<i>Coprosma intertexa</i> , <i>Carmichaelia nana</i> , <i>Celmisia spectabilis</i> , <i>Celmisia magnifica</i> (which is near its southern limit)
Fauna present	Grassland insects, Skinks, Moths (wide variety), Pipits
Threats to values present	Flooding from the Orari River, browntop, sweet vernal, hawkweed (<i>Hieracium pilosella</i> , and <i>H. praelatum</i>), Broom, Fire, Intensive farming, Road works (although there is a landscape protection agreement with the Mackenzie District Council), Rabbits, Rodents, Possum

There is a roadside maintenance agreement with the Waimati Council to ensure that pests are managed and that the size of the road is not significantly increased (see figure 27).

3.2.2 Glenmore Station

Glenmore station is located west of Lake Tekapo and encompasses a large range of montane, subalpine, and alpine vegetation. The covenant itself is over 1000ha of ecologically significant tarns (including the Hartley and Grebe tarns), wetland and tussock land. The station is bounded by the Joseph Valley wetland to the northwest and Fork Stream to the southwest. The most diverse range of kettlehole tarns and other associated glacial landforms in the Mackenzie Basin are found within the covenant. The site undulates and ranges in altitude from 750m to 1000m. Topography includes an extraordinary mix of knob and kettles, hummocks, ridges, outwash channels and numerous tarns. Average rainfall in the area is about 750mm per annum and snow is likely to fall during winter months. This site is a particularly valuable case study as there is a significant amount of outside scientific research being conducted within the covenanted area.

The covenant is divided into two blocks, Sunday block to the south and Peter's block to the north. Sunday block is grazed by 450 mixed age wethers for 3 to 4 weeks, beginning in May and 160-170 ewes to lamb from October to November. Peter's block is grazed by 120 ewes to lamb from October to November and both blocks are grazed by 130 ewes post-weaning for 2 months. Continued grazing with sheep around the ponds and tarns will be essential to control any marginal pasture grasses. An adjacent area to the east of the covenant is grazed by sheep and deer which will provide and a comparison between effects of grazing. The owner sees the covenanted area as important for continuing a balanced use of the property, so the grazing regime will continue unless monitoring suggests otherwise.

The monitoring objectives for this site are set out in the QEII management plan. Monitoring currently consists of photopoints which have been setup around the site by the QEII field

representative. Most show the general condition of the biodiversity and landscape values present (see figure 29). As well as the usual pest management monitoring and physical covenant condition monitoring. Wildlife is also recorded while on site. The key policies in the document that relate to monitoring are as follows:

- Monitor change resulting from natural processes and pastoral farming practices as they may impact on the covenant area
- Ensure potential conflict between management practices and natural processes are properly assessed, and
- Require changed management strategies when and where monitoring suggests necessary

The main objectives of this covenant are:

- a) To protect and maintain the open space values of the land,
- b) To protect native flora and fauna on the land with particular reference to the representative vegetation associations
- c) To protect and maintain the landscape values of the land, with particular regard to the distinctive mix of landforms and tussock grassland and wetland communities
- d) To ensure protection for features on the land with special ecological value
- e) To use the land for pastoral farming, in conformity with objectives (a) to (d) above, while requiring change in management when monitoring proves it necessary.

3.2.2.1 Values present

The tarns and associated wetlands are in a near-natural condition and a wide range of native species are present (see figure 28). A Protected Natural Areas report (PNA) noted that this covenant possessed “the most outstanding area of kettles in the South Island.” The area is complex, consisting of many small and large tarns and morainic hollows. Vegetation ranges from submerged associations to dry depleted fescue grasslands which may be capable of reverting to a high quality community. Wader and waterfowl species breed and feed at the site and it also supports the endangered southern crested grebe. The covenanted area provides habitat for a wide range of bird species and is seen as site of “special wildlife interest.” The tarn margins contain three flora species that are threatened plants in New Zealand. These species are *Crassula peduncularis*, *Iphegenia novae-zelandiae* and *Isolepis basilaris*. Tarns and ponds are considered to be “zoologically and limnologically outstanding.”



Figure 27: Glenmore station photopoint of tarns and surrounding vegetation.



Figure 28: Photopoint of Glenmore Station showing the zone between high and low water levels that has unique vegetation present.

Fauna present pose a threat to the farm itself as well as native species. These fauna species include:

- Rabbits
- Hares
- Ferrets
- Stoats
- Cats

There are large numbers of Canada geese and paradise shelduck, which pose a threat to marginal vegetation in the tarns and other wildlife. Hawkweed (*Hieracium pilosella*) is a problem in tussock grasslands, although rabbit control has seen as increased growth in grassland species. Crack willows are present around Hartley tarn and although they provide habitat for avian fauna they need to be monitored to ensure that they do not get out of control. Military operations adjacent to the site could also pose a threat due to fire and flying debris.

3.2.3 Ohau Downs

Ohau Downs Station is a 1200ha station located at the southern end of Lake Ohau, in the Mackenzie Basin. The terrain is ranges from flat to rolling moraine and outwash, between 550 – 620m asl. The average rainfall is 630mm per annum, but drought like conditions can prevail with northwest wind conditions. The property can be covered in snow for several weeks at a time during winter months. The station includes ice-derived kettlehole depressions that support permanent ponds (Raupo and Swan lagoons) and ephemeral tarns with characteristic short turf vegetation (see figure 30). There is extensive mixed grey scrub (*Discaria* & *Comprosmia*) on terminal moraines of Lake Ohau, and scattered *Cassinia* shrubland on older moraines. There is rich turf vegetation on pond and tarn margins, significant aquatic and semi-aquatic communities. Extensive sedge/rush riparian wetlands are part of the drainage system.

This covenant is currently used entirely for sheep grazing, though it was formerly grazed intensively for a long period with sheep and cattle, and was then regarded as winter wether country. The tarn/wetland/dryland part of the covenant area is used by 700-800 mixed age wethers for 4-5 months of the year. The lake edge block is used by 1100 ewes especially for lambing and 800-900 hoggets winter on this block. Continued sheep grazing around the ponds and tarns will be essential to control marginal pasture grasses. Likewise, wetland management will be dependent on maintaining a good productive cover in the surrounding drylands. Shoreline shrublands are in large part cultural in origin and dependant on good management

for their sustainability. Burning for management purposes is conducted and is envisaged as a management tool to control scrub for stock access around the lake edge.



Figure 29: Ephemeral tarn at Ohau Downs Station, exclosures from other scientific research are located along a transect.

The covenant is regarded as important by the landholder in maintaining a balanced use of the property. For this to continue into the future, monitoring needs to provide accurate information on the vegetation change that is occurring in the covenanted area. It is highly likely that the covenanted area will remain in use, to balance the property, but the levels and types of grazing will need to be used to help benefit the biodiversity values present.

Current grazing will likely continue as it is seen as a contributing factor to the current diversity and condition of the vegetation present.

Current monitoring consists of several photopoints located around the covenant. The management plan lists the objective or goals for monitoring of the covenant as follows:

- Monitor change resulting from natural processes and pastoral farming practices as they may impact on the covenant area
- Ensure potential conflict between management practices and natural processes are properly assessed, and

- Require changed management strategies when and where monitoring suggests necessary

These are fairly broad objectives as the purpose of this covenant is primarily to protect landscape values. The photopoints for this site are quite broad scale because of this. On a site like this where the management plan does not have specific biodiversity goals broad scale monitoring is likely sufficient. Monitoring the effects of grazing is a key policy for monitoring so this covenant is similar to the other covenants used as case studies where monitoring vegetation change in response to management regimes is a key focal point.

3.2.3.1 Values present

The Ohau Downs Station covenant was setup to protect 1200ha of ecologically significant tarn, wetland and tussock grassland communities (see figure 31). The covenant area consists of short-tussock grassland, which has degraded to hawkweed in many places, extensive tarn and alluvial wetland vegetation and shoreline scrub on the southern edge of Lake Ohau. The shoreline shrubland has vigorous native broom and *Coprosma intertexta*, which are seen as a special feature of this covenant. Common kowhai, beech hybrids and wide range of aquatic animals occur on the lake side of the covenant, on Crown land reserved from sale.

A large portion of the covenant was identified as a Protected Natural Area (PNA) in the Mackenzie Ecological Region PNA survey. Some of the morainic dammed tarns support raupo communities while low growing *Carex* and *Scirpus* associations surround others. In comparison there are areas of dry fescue grassland and some of the better drained sites support *Cassinia* communities (limited distribution in the area).

There is rich fauna of wide spread and endemic species. It is a breeding and loafing area for waterfowl and waders including duck, swan, Canadian geese, terns, oystercatcher and black stilt. There are native fish in permanent ponds and streams. Endemic invertebrates and the rare Otago skink are present in stony shrublands.

There are a number of animal pests present that are a threat to farming and native wildlife. Some key threats include:

- Rabbits
- Hares
- Ferrets
- Stoats
- Unauthorised off road vehicles (4WD/trail bikes etc)

- Duck and goose shooting (controlled by owner)
- Transmission lines are seen as a danger to waterfowl and wading birds
- Pinus species (see figure 32)



Figure 30: Tarn and tussock grasslands on Ohau Downs Station.



Figure 31: Plantation forest infiltrating the covenant boundary at Ohau Downs Station.

A number of these high country sites do not have roadside fencing so unauthorised access from vehicles can be a problem. There have been cases where power companies have driven through high country covenants to access downed lines. Councils have also dug holes for metal in covenants unknowingly. For these reason a number of high country covenants have been fenced and signs displayed to show that they are in fact protected areas.

3.2.4 Rakaia Gorge (Tui Creek)

Information for this covenant was unavailable but the values present are similar to those in other high country sites. Red tussock (*Chionochloa rubra*) is the primary value present, with lesser amounts of silver tussock present (*Poa cita*) (see figure 33). The geography of the site is similar to the other high country sites also, with low annual rainfall, cold winters and mild summers. Drainage is also similar to other high country sites with glacial activity leading to a layer of impenetrable material that makes drainage poor and increases runoff.

Monitoring consists of photopoints and informal visual monitoring. Several photographs have been taken around the property and photopoints will then be selected according to which ones are the most beneficial. Threats to the covenant include a plantation forestry located along one of the boundary lines (see figure 34). The covenant contains a grazing clause which allows it to be grazed as part of the ongoing management.



Figure 32: Tui Creek site showing unimproved tussock (right) and improved grassland (left).



Figure 33: Plantation forestry bordering Tui Creek covenant, hawkweed can be seen in the foreground.

4 Chapter Four – Evaluation of current monitoring and a comparison with management plans and frameworks

This chapter will determine whether vegetation monitoring occurring in the field (chapter 3) is sufficient to sustain the biodiversity values that are present. This will be achieved by comparing what monitoring is occurring in the field and then looking at how suitable either the methods currently used are or how suitable alternative methods would be from the review in chapter 2. It should be noted that methods need to be cost effective, efficient and appropriate due to the limited resources available. QEII and LEAF Marque monitoring frameworks will be also assessed as these form the basic structure of any monitoring program that is implemented under their schemes. These are set in place by these organisations to provide a national or in LEAF's case global structure to the monitoring programs being implemented locally. Although current monitoring was only analysed from case studies in the Canterbury region, it is still sufficient to determine whether monitoring follows an organisational template / framework or whether it is mostly at the discretion of regional representatives. It is crucial that these frameworks provide effective biodiversity protection on a broader scale if biodiversity protection is going to be successful.

The most important management aspect of each property is having a clearly defined aims and objectives for monitoring (Clarke, 1986; Daniel & Rasmussen, 1985; Spellerberg, 1991), which could be included in a management plan if one is available. If monitoring has no structure and no direction then it can and likely will fail and be waste of precious resources (Noss, 1999). Uncertainty about monitoring objectives is seen as one of the major constraints to the presentation of results for many studies (Allen, 1993a). It is not possible to monitor everything in an ecosystem and there are a number of variables within each ecosystem that will react differently to certain phenomena. This is where monitoring methods need to be able to measure vegetation change in response to a management variable like grazing and limit noise from other naturally occurring phenomena.

Appropriate monitoring frameworks are crucial if broad scale biodiversity protection is going to be successful. Appropriate management regimes and monitoring methods are crucial for protection on a local scale. QEII field representatives have the skills and knowledge to be capable of monitoring these covenants and providing good information on appropriate management regimes, but monitoring is ongoing and will definitely need to be conducted by another observer at some point in time. Problems with repeating monitoring can arise with permanent staff change over or if the monitoring is required to be conducted by another observer. Problems may also arise when new representatives have not yet gained the necessary botanical and ecological knowledge and experience to make these observations without the support of good data from a sufficient monitoring program.

While ecosystems may be similar across regional boundaries, the management regimes across these boundaries may not. Ecosystems need to be in a similar ecological context and have connectivity with other similar ecosystems to be sustainable (Hobbs & Norton, 2004), which is an important indicator for assessing the significance of an area for protection (Norton & Roper-Lindsay, 2004). This means that ecosystems need to be managed effectively across regional boundaries if biodiversity is to be protected on broader scales (regionally and nationally). Localised problems are primarily with staff turnover, repeating monitoring incorrectly, ensuring monitoring has clear objectives and using methods that are going to obtain enough information with minimum resources. Effective local management is essential for protecting native biodiversity on site, but its effectiveness is diminished if some blocks are being effectively managed and others are not. Variation of management can be intra or inter regional without clear organisational frameworks guiding monitoring programs. For this reason the monitoring frameworks from these organisations that are involved in protecting biodiversity come into focus. If effective protection is not occurring uniformly at a national scale, then the effectiveness of QEII open space covenants or LEAF Marque certification schemes as tools for protecting biodiversity in New Zealand are diminished.

4.1 Organisational frameworks for monitoring (QEII and LEAF)

Lack of clear direction for covenants and objectives for monitoring in particular is a problem (Allen, 1993a). The representatives themselves may have an idea of key monitoring objectives but it would be difficult for a new representative to take over and remain on this direction if it is not clearly documented. Developing objectives and aims for monitoring in all covenants would also allow stake holders and land owners to put the vision of where they see the covenant going into an accessible document. There is a wide range of management issues that need to be addressed on each individual site visit, which could be prioritised according to management plans. Managing these issues in such a short visit time frame does not always allow substantial biodiversity monitoring to be conducted. The key range of threats identified on the monitoring reports need to be managed and monitored ideally by the land manager, unless specialist assistance is required. Monitoring biodiversity values in response to grazing levels may not necessarily be the highest priority in terms of management at a particular time for a site, which would mean that gaps could form in the data for that site if monitoring is too intensive and cannot be conducted in full.

Individual field representatives may be capable of visually monitoring an area and deciding what management regime is most suitable, but this relies on a wealth of knowledge and experience. QEII as a national organisation should consider including management and monitoring frameworks of all grazed covenants that provide a structure or format for the

development of management plans. Even if these frameworks only required 3-5 goals for the covenant it would allow monitoring methods to be selected more accurately. Although every covenant is distinctly different these frameworks can be broad but contain a template of information that should be included. This may include:

- Historical context of the covenant (if available)
- General description of the site
- Legal conditions of the covenant
- Values present in the covenant
- Goals for the covenant
- Grazing regimes
- Monitoring objectives
- Monitoring program (including methods selected)
- Threats
- Public access

Once a document like this has been developed it creates an accessible and readable document that can easily be referred to by land managers and representatives at any time. A lot of QEII's open space covenants are relatively new, so there is plenty of time to develop sufficient monitoring program that will sustain the covenants natural values into the future. Some of the land owners that enter into a covenant are of elderly age and may not always be around to ensure that their original thoughts and ideas for the site are being followed or alternatively a property may be sold on. If these initial goals are documented then the intentions for the covenant will be much clearer. Developing a management plan is not necessarily a time consuming or difficult task if the relative information is available and the land owner is fully involved. If a whole site management plan is seen as too costly, then a well detailed monitoring plan will be sufficient.

At the moment many certifications are marketed as helping to provide sustainable operations, which does involve a small degree of biodiversity protection, but is primarily aimed at making operations more sustainable and less detrimental to the environment. Environmental management plans are necessary to gain the LEAF Marque certification. All members of staff for each site are required to sign to signal that they understand the environmental plan and implications (LEAF, 2008b). With regards to the LEAF Marque certification scheme, there could be more stringent criteria for biodiversity protection rather than just considering the environmental impacts of operations (LEAF, 2008b). The same has also been said of FSC certification for forestry (Bennett, 2000). Criteria could state that an area of significant value needs to be preserved or that an area with potentially significant values needs to be improved

and monitoring results audited to retain certification. There could even be different levels of certification where the higher levels are awarded for concerted protection efforts, although this may be somewhat optimistic, due to the voluntary nature of these tools.

Many land managers see themselves as stewards of their land and many have a genuine interest in protecting any values presents on it. The problem is if you make certifications or legal covenants too stringent then it is likely to turn away potential clients. For certifications there is the added economic incentive for complying with the conditions of each certification. Clients receive increased market access as well as improved brand recognition. Because of this certification schemes probably have a bit more room to include more stringent conditions on biodiversity protection, because clients are still benefiting from the scheme. This statement is specific to New Zealand as there have been questions raised internationally over the benefits outweighing the costs of gaining certification in many developing nations (Gullison, 2003). New Zealand has a unique image of being clean and green and because of our size we have a relatively low production potential and have to rely on niche markets for many of our exports. For these industries certification is very desirable and necessary to gain access and export to these niche markets overseas.

QEII on the other hand have to be a lot more careful of making biodiversity protection measures too restrictive, because the agreements are legally binding and land managers rights to using the land under question are restricted much more so than with certification schemes. Potential covenantors may be turned away by agreements that are too restrictive, as they may be seen as excessive and unnecessary. While QEII covenants are an excellent tool for specifically protecting biodiversity, industry certifications are aimed more at environmental awareness and economical sustainability rather than specific biodiversity protection. Although increased environmental awareness can directly improve biodiversity condition. Industry certifications are still an excellent tool for making land managers, workers and consumers aware of how practices can be made more sustainable and less detrimental to the environment.

Once these plans and objectives have been determined the next step would be to choose appropriate monitoring methods. Selecting appropriate methods is much easier when you are aware of what is to be measured at a site. Trying to recommend or select appropriate methods without having knowledge of the objectives is much more difficult and would not be beneficial for the site. The proportion of sites reviewed as case studies in chapter 3 that have management plans and or monitoring objectives can be found in (table 17).

Recommendations for good design and field methods in monitoring are as follows:

- take an experimental approach to sampling design
- select methods appropriate to the objectives and habitat type
- minimise physical impact to the site
- avoid bias in selection of long-term plot locations
- field markings must be adequate to guard against loss of plots
- ensure adequate spatial replication
- ensure adequate temporal replication
- blend theoretical and empirical models with the means (including experiments) to validate both
- synthesise retrospective, experimental and related studies
- integrate and synthesise with larger and smaller scale research, inventory, and monitoring programmes

(Legg & Nagy, 2006)

Table 17: A summary of monitoring methods and management plans for case studies

Covenant	Monitoring Methods	Management Plan	Well defined Monitoring objectives
Rakaia	Photopoints and general visual	Yes	Yes
Tui Creek	Photopoints and general visual	No	No
Ohau Downs	Photopoints and general visual	Yes	Yes
Glenmore	Photopoints and general visual	Yes	Yes
Eyrewell	Photopoints and general visual	No	No
Mt Alexander	Photopoints and general visual	No	No
Banks Peninsula	Photopoints and general visual	No	No
Collesie	Photopoints and general visual	Being developed	Being developed

4.2 Current monitoring in Canterbury lowland and high country sites

The purpose of this thesis is to determine whether current monitoring is sufficient to sustain current biodiversity values on private land, which involves evaluating frameworks as well as individual monitoring methods. It is clear that there is no one-size-fits-all framework that can be applied to every covenant that is grazed, due to the vast differences in ecosystems found throughout the country. The same is also true for monitoring methods. At present it is difficult to gauge how successful QEII open space covenants have been for protecting or sustaining biodiversity values. This is because (A) they are relatively new and monitoring has not even been repeated yet for a number of covenants and (B) because if there are no goals it is difficult to determine whether changes are desirable or not. One desirable species may have become more abundant but it may have come at the cost of another desirable species. If one of the objectives of the covenant was for species A to increase in abundance then this situation would be seen as a success. Utilising suitable monitoring techniques to measure a change in desired variables is the obvious next step towards sustained biodiversity protection and will vary with each property and the objectives within each property. We know how important protecting biodiversity on private land is, so the more effective organisations like QEII and LEAF are then the better off biodiversity will be.

All of the methods detailed in Chapter 2 have their merits for monitoring vegetation change in response to management regimes (Allen, 1993a). They all however differ with respects to cost effectiveness, intensity and suitability for conservation sites. All of the sites used in this thesis have grazing clauses included in their covenant documents, which allow the covenant area to be grazed as part of the overall management of the property indefinitely. The majority of properties have both exotic and native species present that are palatable to grazing species. Because of this monitoring needs to be particularly sensitive to change caused by grazing with these species, but also cost effective, due to the factors mentioned in chapter 1. Detailed information needs to be obtained on an ongoing basis to obtain a record of change in response to management regimes over time. If this begins with a strong organisational framework for monitoring covenants and leads to appropriate monitoring with appropriate methods then it will bode well for biodiversity.

The case studies presented in chapter 3 show that general visual monitoring in conjunction with photopoints are the primary methods for monitoring in the Canterbury region. Visual methods are used for monitoring general vegetation trends, invasive species and physical condition of the covenant (fences etc), while photopoints are used to monitor certain species or areas of interest in the covenants as well as vegetation change over time. Areas of interest

usually include areas that are grazed most intensely, which also should receive more intensive monitoring as these areas should have the greatest levels of change in response to grazing. General visual monitoring is not repeatable and is not capable of accurately monitoring vegetation change in response to management decisions as it relies solely on the observer's memory of previous vegetation condition. Photopoints are a valid and popular method, particularly with observers that have to monitor vegetation change across broad environments (Hall, 2002; Norton, 2006; Willigen & Grodecki, 2007). Photographs provide a visual record of change that can be used to effectively show succession within the site over time. They are also a very effective tool for generate public interest and awareness in biodiversity and environmental issues (Norton, 2006). Both of the current QEII field representatives in the Cantebrury region believe that photopoints are the most appropriate method for monitoring covenants (M. Giller [QEII] pers. Com., June 24th) (B. Molloy [QEII] pers. Com., June 10th).

If photopoints are going to be the primary or solitary method used for measuring vegetation change then good detailed information needs to be collected with them. This information should include the following:

- Photopoint identification
- Date taken and time taken
- Weather conditions at the time of the photo
- Vegetation type (include at least the top 5 species present)
- The direction that the photo was taken
- The type of photo (panorama, spot etc)

(Norton, 2006)

The photopoints that are currently being used need to be clearly identifiable and each photograph taken needs to be clearly linked to its corresponding photopoint. Climatic data needs to be recorded each time monitoring is conducted as well as the date, time of day and season. If adequate supplementary data is not acquired then you are simply left with an image of the vegetation condition at that point in time and while this may be useful as a supplementary measure of a more detailed monitoring program it is not sufficient on its own merits. Sites must be located where they are not likely to be obstructed by vegetation in the future or where the site may not be accessible in the future, bearing in mind that monitoring may be continued for several decades. This should be taken into account by QEII representatives when they finalise photopoints for current covenants or select photopoints for future covenants.

Current QEII monitoring should aim to have about 15 – 30 designated photopoints per site, although large sites like Ohau Downs and Glenmore Station may require slightly more. With each photograph all of the climatic information listed above should be recorded in a notebook, ensuring that each photograph can be accurately matched up with the corresponding notes. Photopoints are probably the most versatile monitoring method commonly used in New Zealand and certainly one of the most cost effective. However it is not possible to rely upon them as the sole monitoring method in every situation. Care must be taken that they are the most appropriate method for monitoring and that they will be able to measure vegetation in accordance with the objectives of the monitoring. Due to their simplicity observers or land managers may be slightly to relaxed when setting photopoints up or merely take photographs of an area. Resources can be wasted and monitoring can fail if methods are not implemented appropriately and if they do not relate to the objectives of the monitoring.

4.3 Suitability of monitoring methods to be used in monitoring programs for privately protected land

The methods reviewed in chapter 2 will now be reviewed with regards to their suitability to be incorporated or used in QEII monitoring programs. There is a large difference between monitoring vegetation change as part of a detailed scientific study and monitoring it as part of ongoing land management. Scientific studies differ from practical land management as they are generally well funded and the supervisors will have access to students and other staff to help conduct the monitoring. These studies need to show acute responses in vegetation against the variable being measured because studies do not normally last for long periods of time unlike the situation that QEII are faced with. Results need to be determinable by the end of the study period or before resources for the study run out. Scientific studies are also heavily scrutinised to ensure that every detail of the study is sufficient to meet its goals. Scientific studies can provide valuable input into monitoring programs and their suitability for particular situations, but are not directly comparable with practical land management.

Unfortunately for organisations and land managers that are required to monitor land on an ongoing basis, there are simply not enough resources available to conduct the type of monitoring mentioned above. Monitoring is much broader and includes a number of variables that are not specifically related to vegetation change. Fences need to be inspected and repaired if required, exclosures may need to be constructed, pests and threats need to be managed and there may be other issues from the land owners that need to be dealt with. It is not the goal of the land owners or QEII to have the most scientifically robust monitoring program; they simply want to know what is happening in the covenant and whether it is beneficial or

detrimental. Neither QEII nor land owners want to spend endless hours or resources conducting intensive and unnecessary monitoring.

Intensive methods will firstly be examined. Transects, Quadrats and height-frequency methods are all fairly similar with regards to resources and intensity and are often combined in monitoring studies. Quadrats can be used along transects at set intervals (Duncan *et al.*, 2001) and height-frequency methods can be used in both quadrats and transects (Allen *et al.*, 1995; Grove *et al.*, 2002; Mark & Dickinson, 2003). They are very robust and frequently utilised methods for measuring vegetation change (Allen *et al.*, 1983; Dickinson *et al.*, 1992; Duncan *et al.*, 2001; Scott, 1965; Wiser & Rose, 1997). These methods take substantially longer to monitor with multiple observers (Bråkenhielm & Qinghong, 1995; Carlsson *et al.*, 2005) (could be exaggerated more with a single observer) than other less intensive methods (visual estimates, photopoints etc). 46% of 13 studies using quadrats went unreported, 40% of 5 studies using height-frequencies went unreported and 22% of 9 studies using transects went unreported in an appraisal of monitoring methods conducted by (Allen, 1993a). Allen's (1993) appraisal measured the success of monitoring studies indirectly by the form in which their results are presented. Although this appraisal is not a true indicator of success as a number of studies used were government reports, it still provides a coarse guide. The methods listed above will however likely be too demanding on resources to implement in a monitoring program that has a single observer and only short visit times.

Tagged plant monitoring is a good technique for assessing species population size and structure, as well as changes in plant nutrient levels, but has not been applied to other objectives of monitoring {Allen, 1993 #11}. Tagged plant monitoring is also not particularly suited to monitoring tussock grassland areas, due to the density and complexity of identifying individual tussock plants. When plants are in close proximity to one another it can be difficult for an inexperienced observer to determine between individual plants, because of this it is not a recommended method to use for tussock that has a density of >50% (Rose & Platt, 1990). Biomass monitoring is not suitable for use as a conservation monitoring technique if samples are removed and taken to a laboratory for detailed analysis. This practise is too destructive and is not repeatable. However if biomass estimates are determined indirectly from height-frequency data then the data can be informative for studies measuring vegetation change in response to a management variable, because they indicate vegetation structure as well as composition (Allen, 1993a; Wiser & Rose, 1997). Biomass data is also applicable to all the objectives of monitoring except population trends in rare species (Allen, 1993a). So biomass measurements may be suitable to monitor vegetation change in response to nearly all monitoring objectives, but they are still an intensive and possible destructive method. If height-frequencies are required to provide estimates for biomass then the same reasons given

above are applicable for why they are not necessarily suited to ongoing monitoring on privately protected land.

Needle point monitoring has been specifically developed for land managers to monitor grasslands (Allan *et al.*, 1998; Tidmarsh & Havenga, 1955). It is a simple method that is fairly objective for selecting which plants are to be recorded. It provides enough information to determine species frequency and will detect vegetation change in response to management decisions (Allan *et al.*, 1998; Tidmarsh & Havenga, 1955). One downfall is that the observer has to carry the measuring device in the field, which can often be through very dense shrub land. The design of the wheel device would make it difficult to carry through some of these areas. If this is a major problem then a tape measure and a pointer can be used instead (Allan *et al.*, 1998). Transects will need to be set up and maintained to allow for future repetition although they do not require sampling areas set out along each transect. Needle point methods are suited to monitoring these environments and could definitely be considered for use if measuring species frequency is an objective of the monitoring. There are a number of variations of this method including throwing a Frisbee or monitoring species that come into contact with the end of the observers but. The virtue of plot less methods is the ease and rapidity with which they can be used. Nevertheless ease and rapidity must always be weighed against sampling bias due to non-random distribution patterns of the plants being monitored.

Formal visual monitoring is accurate enough to detect vegetation change in response to management decisions and it is repeatable (Scott, 1989). This method also takes less time than other more intensive methods (Bråkenhielm & Qinghong, 1995; Carlsson *et al.*, 2005; Scott, 1989). Resource demands do increase with the need to maintain permanent plots so that the monitoring can be accurately repeated. Simple quadrats would be the most suitable plot to use for this type of monitoring. Observers would need to locate the samples within the site and then visually rank species within them. This would take longer than monitoring with only photopoints but if the two were used jointly then the monitoring would have much more detailed information on vegetation change, but again it depends on the objectives of the covenant to determine if it necessary. Once the plots are established then monitoring could be conducted relatively quickly on each visit. No specific monitoring equipment is required so observers will not have to carry any bulky equipment or measuring devices. For cost effectiveness and efficiency visual monitoring would be the next best technique behind photopoints.

Photopoints are the most cost effective method for monitoring vegetation change. They require few specific resources and are easily repeatable by unskilled observers. They are widely used in studies involving tussock grasslands in New Zealand. 26% of studies in the appraisal conducted by (Allen, 1993a) used photopoints. If photopoints are going to be used as a sole method for monitoring caution must be taken to ensure that they will be sufficient to

measure the desired variables against the monitoring objectives and that no other methods are necessary. Ensuring that the photopoints are set up correctly and that all the relevant information is being obtained is critical if this method is going to be sufficient for monitoring vegetation change. There are a number of field guides for using photo monitoring (Crimmins & Crimmins, 2008; Hall, 2002; Norton, 2006; Willigen & Grodecki, 2007) and if this technique is going to be used then the methods should be followed precisely. Photographs provide an excellent visual reference for a site even if they are not being used as a monitoring method. They are also a valuable educational tool for promoting environmental awareness and initiating public enthusiasm towards biodiversity projects.

There is no simple way of recommending a particular monitoring method to fit a particular set of circumstances so methods will need to be selected on their ability to measure the desired variables as set out in the monitoring objectives. Methods are being assessed on their cost effectiveness and suitability for monitoring where resources are tightly restrictive (see table 18). Any information that is not required should not be collected, which means that the more intensive methods like height – frequencies are providing information that may not be required. It would be ideal if ample information could be obtained and as much information as possible could be analysed, but it is simply not practicable for conservation on private land. Land owners, representatives and auditors aren't interested in wading through excessive amounts of data to find what they are looking for. Land owners are generally interested in basic monitoring programs that are simple and effective.

Table 18: Comparison of the most cost-effective methods reviewed.

Most cost-effective methods	Scale	Repeatability	Information content of vegetation change
Photopoints	Landscape and spot	Easily repeated	If correct information is obtained then the information content will be low to moderate
Visual Rank	Site	Moderate	Moderate - primarily to obtain species rank (abundance)
Needlepoint	Site	Difficult when compared to photopoints and	Moderate – primarily to determine species frequency

5 Chapter Five – Conclusion and recommendations

A critical component of the protection of biodiversity values is to find the correct balance between the cost effectiveness of the methods used and the information content that can be gained from each method. The determining factor is often the amount of resources available to land managers / owners and representatives from organisations involved with biodiversity protection. Funds are often limited because the benefits from protecting biodiversity with open space covenants are voluntary and the benefits are generally altruistic rather than financial. Finding a balance between information content and cost effectiveness is an important factor for implementing an appropriate monitoring program from the outset. Scientific monitoring programs can be fairly adaptable in terms of changing or adapting the methods used in relation to how the site is progressing or in response to changing scientific questions (Lindenmayer & Likens, 2009). It would be much more beneficial to begin a non scientific monitoring program by gaining good information from the outset so that additional resources are not required to drastically alter the program and so that initial resources are not wasted.

Without goals set in place there is no benchmark to refer to when gauging how successful a covenant has been at sustaining biodiversity values. If there are no goals, there are no criteria to ascertain whether vegetation change in one species is beneficial over another. If, for instance, the goal of a covenant was to improve associations between *Sophora microphylla* and *prostrata* (Collessie covenant) then the management would be successful if these species showed an increased abundance or frequency at that site. QEII do not supply information on the ‘success’ of covenants with their statistics, although they do state that QEII monitoring shows the majority of covenants meet not only the terms and conditions of their covenants but exceed them (QEII National Trust, 2008). With improved monitoring and reporting then QEII have a unique opportunity to build a database of vegetation condition on private land or contribute to an existing national vegetation database.

With regards to the question: is monitoring sufficient to sustain biodiversity values on private land? Answering this question outright requires two things, otherwise it is very difficult to determine concretely without clear evidence. This is due to (A) if there have been no goals set for the covenant it is difficult to determine if vegetation change to date has been desirable and in line with the direction of the covenant and (B) monitoring has only just begun for many covenants and has not yet been repeated for the majority of covenants used as case studies. When QEII’s national frameworks require goals to be set for each site and monitoring has been conducted for a reasonable period of time then it will be clear whether current monitoring is sufficient. Currently numerous photopoints have been taken at each site for the sites used as case studies but a final selection has not yet been made as to which ones are to be used on a

regular basis. In the early stages of monitoring it is better to take more photographs and discontinue some rather than taking too few and having to add more in the future.

From a scientific perspective current monitoring would not be sufficient to sustain biodiversity values present at these sites. Some of the sites will require another more intensive measure like needle point or visual rank to monitor intensely grazed areas. At the moment it appears that the current QEII model relies more on the representatives than monitoring to make management decisions. Well these representatives may be capable of making these decisions, QEII need to include a more rigid framework for field monitoring methods and reporting. The duration of the monitoring programs in question is an important factor to consider. Open space covenants are placed on a site in perpetuity which means monitoring also follows this timescale. The monitoring programs should be developed in a way that allows the monitoring to be easily replicated by land managers or other observers. This will mean that the monitoring will continue unhindered into the future and can be 'weaned' off the representatives if required.

It was mentioned in chapter 4 that a number of studies (63%) were seen to have failed that used photopoints as the primary method for monitoring. This is likely due to the type of studies that counted in this data as many were government commissioned reports. However, care should be taken when photopoints are seen as the 'go to' method for monitoring due to its simplicity and repeatability if they are not conducted in an appropriate manner. Care should also be taken when using photopoints to specifically monitor individual plants in dense tussock grasslands, due to the difficulties in identifying plants while ranking the photograph. If photopoints are to be used and in most cases they should be, even if it is supplementary, then strict guidelines should be followed and all complimentary information should be recorded and stored (Crimmins & Crimmins, 2008; Hall, 2002; Norton, 2006; Willigen & Grodecki, 2007). Complimentary information includes, laying down a grid in the photopoint to provide scale to photograph. One square of the grid could also be used for spot photographs. Climatic information and notes should be taken, but these need to be stored with the corresponding photograph and where they can be easily accessed for comparisons. An important thing to remember when setting photopoints is to ensure that future vegetation will not obscure the photographs in the future.

The ideal situation for biodiversity protection on private land would be to have a well developed management plan for each site, which includes goals and objectives for the covenant (Norton, 2008). This management plan would provide a background for a monitoring plan to be based on. Monitoring goals can then fit in with the goals of the entire property. This would involve deciding what aspects of the covenant are to be monitored more specifically and any species that need to be monitored more closely. Even if a management plan is not seen as necessary then a smaller monitoring plan should be drafted that includes goals and

objectives for where the land owner and representative feel the covenant is going. Without this assessing the covenant and even managing the covenant will be much less effective and is another reason why current monitoring is not sufficient. Many landowners place a covenant on their property to ensure that it is protected in perpetuity, but the way in which the covenant is managed is not as clear cut. If goals are created then it provides a direction and a structure to the management of the property and most importantly for monitoring. Having goals provides a benchmark in which monitoring results can be measured against. Even if a baseline survey has been conducted, it only provides a snap shot of the biodiversity condition at that point in time. The composition of species is likely to change, whether it is for the better or for the worse. Monitoring goals can help determine which direction is for better and which is for worse.

Establishing management and monitoring plans also provides an opportunity for the representative and the land owner / manager to develop a detailed direction for the covenant. Once the management or monitoring plan has been developed then the most appropriate monitoring methods need to be selected. It is a good idea if using subjective methods to use them in conjunction with objective methods. Management plans do not have to be large and especially not excessive for covenants. The more detailed and to the point they are the more effective they will be. A simple well outlined plan is the most effective. For large high country properties a whole property management plan would be a good idea as this could include a covenant if one was present. Common steps towards developing a whole property management plan are as follows:

- Deciding that a management plan is necessary for the property
- Collating underlying information on the property – environmental, management, social
- Defining goals for the property
- Adapting the management plan template to fit the property
- Implementation of the management plan including monitoring and review

(Norton, 2008)

Ecological monitoring literature recommend that monitoring should be conducted at that same or a similar part of year in a particular season so that the flora is in a condition where it is most easily monitored, as different species have different cycles of activity (including seasonal, diurnal and tidal) (Clarke, 1986; Goldsmith, 1991; Spellerberg, 1991). In New Zealand this period would be January through March as species will have seeds and flowers heads present, which will help in identifying them. Due to these constraints on monitoring it may be necessary to prioritise ecosystems or species according to their importance either internationally or nationally (Goldsmith, 1991). QEII's rating system could be used to determine a hierarchy for monitoring intensity or management importance. With the optimum

vegetation monitoring window for many ecosystems being relatively small (usually a single season), there is little time for the representative to conduct adequate monitoring. High priority sites could be monitored during this 'peak season' each time and lower priority sites can be monitored where possible at a similar time each year. The lack of funding and hence lack of human resources severely restricts the monitoring capabilities of the QEII trust, which means that this aspect may have to be disregarded in some situations. Ensuring that monitoring is conducted at a similar time of year is achievable and should be implemented.

Few studies have integrated the range of disciplinary perspectives essential for the prioritisation and evaluation of conservation management (Hughey *et al.*, 2003). For better use of resources currently available (Hughey *et al.*, 2003) argues that decision-makers need to ask (1) where should scarce resources be invested in conservation management? And (2) which investments in conservation management have been the most successful? To answer these questions, decision-makers need to use cost-effectiveness analysis and cost-utility analysis to improve the conservation of threatened and endangered species (Hughey *et al.*, 2003). Gaining overall figure estimates is valuable, but it would be much more valuable to gain values based on biodiversity condition or individual species per unit so that more accurate assessments can be made in the trade off of biodiversity loss for development on a case by case basis. There are also few published studies regarding the effects of a release from grazing in semi-arid short tussock grasslands in New Zealand (Allen, 1993), which shows that if covenants that have been grazed for a long period time are released the results will be largely unknown. Further understanding of threat pathways and invasion epidemiology's would also be beneficial to improve pest management.

Currently the majority of QEII open space covenants are monitored by the appropriate regional representative, which in most cases is a single person for an entire region. This representative is required to monitor all existing covenants on a two yearly basis, promote new covenant acquisitions as well as draft and implement management plans for new covenants. In 2004, a total of 146,280 hectares were registered as privately protected land. By June 2006 privately protected land through QEII and Nga Whenua Rahui covenants reached a total of 221,473 hectares, which is a 51.4% increase over just a two year period (MfE, 2007). This massive increase of workload is passed directly on to the QEII organisation and subsequently to the representatives. Monitoring is supposed to be conducted at a similar time of the year each time, although there are constantly new covenants being registered and added to representative's workloads. QEII relies on representatives building a solid rapport with land owners as a critical part of their success, but if more and more covenants are added then there will be less time for visits. This is of course unless there is an increase in funding and more representatives are added to each region.

An appraisal by Allen (1993) contained records of scientific studies that included a total of 62 combinations of objective and method. Several studies had more than one objective and/or used more than one method. Most (45%) studies were intended to monitor changes in vegetation resulting from management of grazing, including complete exclosure of animals, control of feral ruminant numbers, and changes in the grazing regime of sheep. Change in tussock grasslands can be measured successfully by all of these methods. However, the usefulness and scientific acceptability of the results that can be obtained by different methods evidently vary widely, and do not always seem to have influenced the choice of method. This has resulted in a substantial waste of resources, and in important opportunities foregone for increasing understanding of the ecology and management of tussock grasslands (Allen, 1993a). Resources are one of the most restrictive factors when choosing which methods to use. It may be desirable to use a number of methods in conjunction with each other but the practicalities for land managers often suggest otherwise.

QEII provide some funding for covenant costs (usually matching the land owners contribution), but they should not be seen as a primary funding organisation. Local and central government should be the primary sources of funding for these covenants, as QEII's resources are limited and could be better spent on management and monitoring. QEII's Canterbury representatives spend a lot of time applying for funding from a range of funding 'pools.' This is a crucial means of getting covenants agreed to by landowners. The costs involved with implementing an open space covenant are not cheap, mainly due to the costs of fencing. To be managed effectively covenants need to be fenced to exclude grazing and if grazing is permitted so that it can be managed. Costs are obviously increased with covenant size and the extent of existing fences. These costs can be reduced by selecting the most cost efficient fencing and by utilising as much existing fencing as possible. This may lead to covenants being slightly varied from their optimum extent or may exclude biodiversity values that are desirable. Obtaining additional funding from these 'pools' is crucial for reducing covenant costs and making QEII covenants more viable.

The amount of resources available to QEII is a key aspect of any management and monitoring decisions and needs to be fully considered otherwise it may not be possible to implement. Resources are tightly restricted, but this does not mean that monitoring cannot be improved or implemented correctly. Monitoring can be made as efficient and cost effective as possible while still obtaining sufficient information. One of the key issues identified during this research is the amount of time field representatives can spend managing pests that should by right be managed by land owners under the regional biodiversity strategy (ECan, 2006). The strategy states that landowners are responsible for the control of most pests on their property. ECan controls pests when they are new to the region, when control methods require technical expertise (e.g. biological control), and when coordinated control gives benefits to the region as

a whole (ECan, 2006). Considering QEII recommend that representatives should spend approximately 3 hours total per covenant visit (M. Giller [QEII] pers. Com., June 24th), time could be better spent monitoring and implementing management plans as specialists. That is not to say that a small degree of pest management should not be conducted while on site if necessary and not time consuming.

Both QEII open space covenants and industry certifications for biodiversity protection on private land in New Zealand are relatively new. There is not a lot of literature or information available on their successes or failures in terms of biodiversity values. The industry certifications that were examined were designed primarily to promote sustainability in the agriculture industry and improve biodiversity condition through awareness. Industry certifications are a valuable tool for promoting environmental sustainability and there is potential for their role in biodiversity protection to evolve and become stronger in the future. If they are really going to be beneficial on a global scale the benefits attained from gaining certification will need to increase to get more industries and companies on board in developing nations or nations that do not require access to particular markets (Bennett, 2000; Gullison, 2003; Kiker & Putz, 1997; Nunes & Riyanto, 2005; Ridolfi *et al.*, 2008; Vine *et al.*, 2001). Cost effective monitoring methods will play a crucial role in the successful implementation of industry certifications. The most cost effective methods found in this research (photopoints, needle point and visual) would be valuable methods for use with industry certifications.

QEII open space covenants are an excellent tool designed specifically with the intention of protecting biodiversity and landscape values in New Zealand with legally binding agreements (Donahue, 2003; Saunders, 1996). They provide the necessary protection for biodiversity, but the ongoing management needs to be backed up with good, detailed monitoring to ensure that the optimum protection is being obtained. Because the trust is young and resources are limited, monitoring should have a good structure and use appropriate methods from the outset to avoid realising that monitoring is not sufficient (Legg & Nagy, 2006). If QEII do not get it right then land owners will likely lose confidence in the covenanting process. Because voluntary recruitment is the primary channel for new clients this could be detrimental to the uptake of new covenants.

There is still a vast amount of research required before biodiversity protection on private land can be integrated accurately into economic models. Fully factoring the financial value of biodiversity into the economy is an important step towards having the appropriate levels of funding. At the moment funding is probably the primary barrier to effective management of biodiversity in New Zealand. It would be a good indicator of how successful covenants have been at protecting biodiversity values in a few years time, when the monitoring plans have been fully developed and implemented. There will also be results from the monitoring to

compare. A number of the properties used as case studies had two sites that were managed similarly but had separate grazing regimes, which could provide good comparisons for QEII.

For a number of the highland sites other scientific research is being conducted which could be incorporated into QEII monitoring or give more detailed information on the covenant.

Universities and other institutions could get involved with QEII for projects. There could be the potential for students to conduct monitoring for covenants as a scholarship or project.

Students could be encouraged to do monitoring as summer work with university based incentives. For example as part of a course students could study a particular site in more depth. This could educate people and raise awareness about some of the issues facing biodiversity protection on private land and its importance.

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7 Appendices

Appendix 1: structure for information to be collected by QEII representatives

Specific Block Information - Resource Description & Evaluation

Blocks :

This information is specific to each block – Fill out a copy of this for EACH block

Single block covenant? Y / N

If Multiple blocks

Note that you'll need to attach a copy of Appendix 4
for EACH block

Number of blocks in covenant:

Block Code <i>(circle one):</i>	A	B	C	D	E	F	G	H	I
Covenant name <i>(if applicable):</i>									
Block Name: <i>(e.g. wetland)</i>									
Brief description: <i>(Enter by block in Description > Supplementary Details > Covenant summary)</i>									
Map Reference:	<i>(can either provide Map ref or Easting/Northing)</i>								
Easting:	<i>(can either provide Map ref or Easting/Northing)</i>								
Northing:	<i>(can either provide Map ref or Easting/Northing)</i>								
Estimate Ha:									
Block Value Rating :	1	2	3						

Block description: (Will be summarised for entire covenant by HO Field)

Topography:	
Aspect:	
Erosion:	
Water Regime:	

Rainfall:	
Altitude:	
Geology:	
Soils:	

(Tick relevant boxes)

☐

Requires fencing

☐

Has species map

☐

Has Weed / Pest map

Other threats:	
-----------------------	--

Blocks .

Ecological ranking:

	H/M/L	Notes
Connectivity		
Rarity		
Diversity pattern		
Distinctness		
Size and shape		
Representativeness		
Sustainability		

Blocks > EMUs .

Ecological management units:

	EMU1	EMU2	EMU3	EMU4
Vegetation type				
Bioclimatic type				
Ecological history				
Hydrology				
Structural class				
Landform				
Spatial contiguity				
% of area				
Must add to 100% for this block				

**Appendix 2: QEII structure for collecting information on Covenant blocks as part of an
initial monitoring report**

- As a minimum identify the key species in each canopy layer, and any special species, including DOC threat categories, regional rarity and unusual populations.
- If a species occurs in different canopy categories in different blocks (e.g. Emergent and Canopy in Block A but only Canopy in Block B), then note this on an additional line i.e. need two lines for this species.
- When entering in the database start with the block with most species, you can copy these across to another block, then add and/or delete species as required.
- When entering in the database – make sure you are entering for the correct block!

[illegible]

	Tick appropriate category								Present in Block									
Species	Emergent	Canopy	Understorey	Ground-cover	Epiphyte	Indicator	Edge	Condition	Trend	A	B	C	D	E	F	G	H	I

Condition; Good, Fair, Poor

Trend, Improving, Stable, Deteriorating

Blocks > Vegetation .

Record notes about any special species, including DOC threat categories, regional rarity and unusual populations.

Species	Notes

Blocks > Vegetation > Vegetation condition .

When entering in the database – make sure you are entering for the correct block!

	Block condition G / F / P									Block trend I / S / D								
Block	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
Emergent																		
Canopy																		
Understorey																		
Ground-cover																		
Epiphyte																		
Indicator																		
Edge																		

	Block	Notes
Emergent		
Canopy		
Understorey		
Ground-cover		
Epiphyte		
Indicator		
Edge		

Insert more lines if required

Block > Wildlife .

- As a minimum identify the key species and any special species, including DOC threat categories, regional rarity and unusual populations.
- When entering in the database start with the block with most species, you can copy these across to another block, then add and/or delete species as required.
- When entering in the database – make sure you are entering for the correct block!

Species	Observation type	Abundance	Number seen	Condition	Present in Block								
					A	B	C	D	E	F	G	H	I

Observation type, **Sighting,** **Signs or Track,** **Heard,** **Capture**

Abundance; **Dominant,** **Abundant,** **Occasional,** **Rare**

Condition; **Good,** **Fair,** **Poor**

Blocks > Wildlife

Record notes about any special species, including DOC threat categories, regional rarity and unusual populations.

Species	Notes

Blocks > Threat management .

When entering in the database – make sure you are entering for the correct block!

[illegible]

Open Space **Blocks > Values .**

- ***This section replaces the section called special features in the old OSC report.***
- If a Block contains nothing unusual or interesting leave **Rank AND Notes** field **blank**. Anything that has a rank assigned to it will be included in the Board report.
- Note that this information will be part of the proposal report to the Board. Please be as brief as possible.
- Insert more lines if you have more Blocks.
- When entering in the database – make sure you are entering for the correct block!

Value	Block	Rank (H/M/L)	Notes (300 character limit on this field)
Biodiversity-Fauna	A		
	B		
	C		
Biodiversity - Flora	A		
	B		
	C		
Biodiversity - Habitat	A		
	B		
	C		
Cultural / historical / Archaeological	A		
	B		
	C		
Geological / soils	A		
	B		
	C		
Visual landscape	A		
	B		
	C		
Recreational / educational	A		
	B		

	C		
Water & Soil Conservation	A		
	B		
	C		

Block – Overall Blocks > Notes

- Note that this information will be part of the proposal report to the Board. Please be as brief as possible.
- If Block contains nothing unusual or interesting leave Notes field blank.
- Insert more lines if you have more Blocks.
- When entering in the database – make sure you are entering for the correct block!

	Block	Notes
Overall health	A	
	B	
	C	
Overall Trend	A	
	B	
	C	
Edge Effects	A	
	B	
	C	
Sustainability	A	
	B	
	C	
Vegetation	A	
	B	
	C	

	Block	Notes
Wildlife	A	
	B	
	C	

Appendix 3: QEII framework for monitoring reports

MONITORING REPORT

Covenant number	5/11/	QEII Rep	Miles Giller	No. of blocks	
Open Space Type					
Owner Names					Last visit Date
Contacts					Last visit Type

Visit

Visit Date		ADHERENCE	
Next visit due		Next visit reason	
Action Taken		Action to take	Rep: Head office:
Time of day		Hours in Cov	Weather
Summary			
Notes			

Boundaries

Block	Boundary type	Location	Est. length (m)	Fence post type	Fence batten type	Mesh Y/N	Other fence type	Post space (m)	#. Plain wires	#. Elect. Wires	#. Barb. wires	#. Rails	Condition & Notes

Ecological Management Units – if missing from the database

Vegn Type	Bioclimatic Type	Eco History	Hydrology	Structural Class	Landform	Spatial Contiguity	% Area

Vegetation > Condition History

Vegn category	Last Cond'n	Last Trend	This Cond'n	This Trend	Notes
Emergent	-	-			
Canopy					
Understorey					
Groundcover					
Indicator species					
Edge					

Threatened / Special Interest Species

Name	Classification	Notes

Wildlife recorded during visit

Species	Observation type	Abundance	Number seen	Condition	
					Observation type , Sighting, Signs or Track, Heard, Capture
					Abundance ; Dominant, Abundant, Occasional, Rare
					Condition ; Good, Fair, Poor

Threats

Threat species	Prevalence	Severity	Mgmt Aim	Priority	Is Achieved	Threat notes
	H/M/L	H/M/L		H/M/L	Y/N	

Public Use and Owners commitment

Public use level		Condition of use		Visitor suitability	
Publicity potential		Interest level		Privacy Level	
Owners Commitment			Commitment level		

Facilities

Facility type	Status	Condition	Facility notes

Photopoints

Signed:

Date: